# Accelerated Learning and Retention: Literature Review and Workshop Review

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# Abstract

Defence Research and Development Canada (DRDC) Toronto and the Canadian Defence Academy (CDA) have embarked upon a collaborative research effort to identify the most promising topics for Research and Development (R&D) on accelerating learning and maximizing knowledge/skill retention that could yield the greatest benefit to the Canadian Forces (CF) within five years. This report examines the two deliverables of this project, a literature review and a workshop.

The literature generated a list of potential research concepts related to accelerated learning and retention. A review of 26 articles from the relevant literature showed a range of factors likely to impact on learning and retention. These included characteristics of the student (e.g., cognitive ability and motivation), the instructor, delivery media (e.g., classroom-based instruction vs. computer-based instruction), delivery methods (e.g., scheduling, feedback and testing) and issues related to retention. It was noted that the factors that influence skill acquisition are not necessarily the same ones that influence skill retention. The literature review examined the available research exploring the impact of these factors on learning and retention, and identified gaps and emerging research questions.

Following the identification of these 15 research topics, a workshop (coordinated and facilitated by the CDA) was convened in Kingston, Ontario in order to explore the merit and importance of these topics from the perspective of subject matter experts, in order to guide future research and development efforts. Thirteen stakeholders, representing Navy, Army and Air force, discussed and provided ratings on each of the 15 topics on each of 11 evaluation criteria such as the scientific merit of the topic area, its alignment with CF/DND goals, and the potential for national or international collaboration on the topic.

Quantitative results showed that simulator-based instruction was rated as being the most promising area for future research, followed by instructor attributes, collaborative learning, distance learning and computer-based instruction. Participants also provided rich insights about each of the 15 topic areas, and raised potential research questions that could be addressed in future research and development efforts.

# Résumé

Recherche et développement pour la défense Canada (RDDC) - Toronto et l'Académie canadienne de la Défense (ACD) collaborent à un projet de recherche sur les sujets de recherche et développement les plus prometteurs concernant les façons d'accélérer l'apprentissage et de maximiser la conservation des connaissances et des compétences acquises qui pourraient être les plus avantageuses pour les Forces canadiennes (FC) au cours des cinq prochaines années. Le présent rapport fait le point sur deux réalisations du projet : une analyse de la documentation parue sur le sujet et un atelier.

L'analyse de la documentation a permis d'extraire une liste de concepts de recherche potentiels liés à l'apprentissage accéléré et à la conservation des connaissances. L'analyse de 26 articles a mis au jour une gamme de facteurs susceptibles d'influer sur l'apprentissage et la conservation des connaissances acquises. Il s'agit notamment des caractéristiques de la personne qui apprend (p. ex. : sa capacité cognitive et sa motivation), de l'instructeur, des moyens utilisés pour donner la formation (p. ex. : enseignement donné en classe ou enseignement informatisé), des méthodes d'enseignement utilisées (p. ex. : établissement du calendrier de formation, rétroaction et examens) et des questions relatives à la conservation des connaissances acquises. On a fait observer que les facteurs qui influent sur l'acquisition des compétences ne sont pas nécessairement les mêmes que ceux qui influent sur la conservation des connaissances et des compétences acquises. Lorsqu'on a analysé la documentation sur le sujet, on s'est penché sur l'incidence de ces facteurs sur l'apprentissage et la conservation des connaissances et on a relevé des lacunes ainsi que des nouvelles questions sur la recherche.

Après avoir recensé quinze sujets de recherche, on a organisé un atelier (coordonné et animé par l'ACD) à Kingston au cours duquel on a exploré les mérites et l'importance de ces questions du point de vue des spécialistes pour guider les travaux futurs de recherche et de développement. Treize intervenants, représentant la Marine, l'Armée de terre et la Force aérienne, ont participé aux discussions et coté chacun des quinze sujets en regard de chacun des onze critères d'évaluation, comme le mérite scientifique de la discipline concernée, sa pertinence par rapport aux objectifs des FC ou du MDN et le potentiel de collaboration au niveau national ou international.

Les résultats quantitatifs obtenus montrent que l'instruction par simulateur est considérée comme le secteur le plus prometteur pour la recherche future, suivie des caractéristiques des instructeurs, l'apprentissage en collaboration, l'apprentissage à distance et l'instruction par ordinateur. Les participants ont également donné des points de vue très éclairés sur chacun des quinze sujets et fait part de questions de recherche potentielles pour les futurs travaux de recherche et de développement.

# Executive summary

## Accelerated Learning and Retention: Literature Review and Workshop Review:

**Adams, B.D.; Karthaus, C.; Rehak, L.A.; DRDC Toronto CR 2011-105; Defence R&D Canada – Toronto; March 2011.**

**Introduction or background:** Defence Research and Development Canada (DRDC) Toronto and the Canadian Defence Academy (CDA) have embarked upon a collaborative research effort to identify the most promising topics for Research and Development (R&D) on accelerating learning and maximizing knowledge/skill retention that could yield the greatest benefit to the Canadian Forces (CF) within five years. This report examines the two deliverables of this project, a literature review and a workshop.

The goal of the literature review was to generate a list of potential research concepts related to accelerated learning and retention. This review required examining 26 articles from the relevant scientific, military and related literature relevant to the question of accelerated learning and retention. Although the literature related to accelerated learning was somewhat underdeveloped, the review showed a range of factors likely to impact on learning and retention. These included characteristics of the student (e.g., cognitive ability and motivation), the instructor, delivery media (e.g., classroom-based instruction vs. computer-based instruction), delivery methods (e.g., scheduling, feedback and testing) and issues related to retention; noting that the factors that influence skill acquisition are not necessarily the same ones that influence skill retention. The literature review examined the available research exploring the impact of these factors on learning and retention, and identified gaps and emerging research questions.

Following the identification of these 15 research topics, a workshop (coordinated and facilitated by the CDA) was convened in Kingston in order to explore the merit and importance of these topics from the perspective of subject matter experts, in order to guide future research and development efforts. Workshop participants were provided with definitions of the topic areas to ensure common understanding, and they assembled into break-out groups facilitated by CDA personnel. A total of 13 stakeholders, representing Navy, Army and Air force, discussed and provided ratings on each of the 15 topics on each of 11 evaluation criteria. These criteria included the scientific merit of the topic area, its alignment with CF/DND goals, and the potential for national or international collaboration on the topic. Participants rated the importance of each topic on each criterion using a rating scale.

**Results:** The results of the workshop were analyzed from both qualitative and quantitative perspectives. Qualitative remarks made by the participants provided rich insights about each of the 15 topic areas, in terms of how they are defined and the issues within each area that are relevant to their own organizations. They also raised potential research questions that could be addressed in future research and development efforts. Quantitative analyses of the importance ratings showed that simulator-based instruction was rated as being the most promising area for future research, followed by instructor attributes, collaborative learning, distance learning and computer-based instruction. However, importance ratings for all topics were very closely spaced. Moreover, even the lowest rated topic, namely scheduling, was rated as being above the midpoint

of the rating scale, suggesting that participants saw all 15 topics as relevant and worthy of research attention.

**Future plans:** This information will be used to guide future research and development efforts.

# Sommaire

## Accelerated Learning and Retention: Literature Review and Workshop Review:

**Adams, B.D.; Karthaus, C.; Rehak, L.A. ; DRDC Toronto CR 2011-105 ; R & D pour la défense Canada – Toronto; Mars 2011.**

**Introduction ou contexte :** Recherche et développement pour la défense Canada (RDDC) - Toronto et l'Académie canadienne de la Défense (ACD) collaborent à un projet de recherche sur les sujets de recherche et développement les plus prometteurs concernant les façons d'accélérer l'apprentissage et de maximiser la conservation des connaissances et des compétences acquises qui pourraient être les plus avantageuses pour les Forces canadiennes (FC) au cours des cinq prochaines années. Le présent rapport fait le point sur deux réalisations du projet : une analyse de la documentation parue sur le sujet et un atelier.

L'analyse de la documentation a permis d'extraire une liste de concepts de recherche potentiels liés à l'apprentissage accéléré et à la conservation des connaissances. L'analyse de 26 articles a mis au jour une gamme de facteurs susceptibles d'influer sur l'apprentissage et la conservation des connaissances acquises. Il s'agit notamment des caractéristiques de la personne qui apprend (p. ex. : sa capacité cognitive et sa motivation), de l'instructeur, des moyens utilisés pour donner la formation (p. ex. : enseignement donné en classe ou enseignement informatisé), des méthodes d'enseignement utilisées (p. ex. : établissement du calendrier de formation, rétroaction et examens) et des questions relatives à la conservation des connaissances acquises. On a fait observer que les facteurs qui influent sur l'acquisition des compétences ne sont pas nécessairement les mêmes que ceux qui influent sur la conservation des connaissances et des compétences acquises. Lorsqu'on a analysé la documentation sur le sujet, on s'est penché sur l'incidence de ces facteurs sur l'apprentissage et la conservation des connaissances et on a relevé des lacunes ainsi que des nouvelles questions sur la recherche.

Après avoir recensé quinze sujets de recherche, on a organisé un atelier (coordonné et animé par l'ACD) à Kingston au cours duquel on a exploré les mérites et l'importance de ces questions du point de vue des spécialistes pour guider les travaux futurs de recherche et de développement. Les participants de l'atelier ont reçu des définitions et des sujets faisant en sorte que tous aient une compréhension commune et ont été répartis en petits groupes animés par le personnel de l'ACD. Treize intervenants, représentant la Marine, l'Armée de terre et la Force aérienne, ont participé aux discussions et coté chacun des quinze sujets en regard de chacun des onze critères d'évaluation, comme le mérite scientifique de la discipline concernée, sa pertinence par rapport aux objectifs des FC ou du MDN et le potentiel de collaboration au niveau national ou international. Les participants ont coté l'importance de chaque sujet en fonction de chaque critère en utilisant une échelle de cotation.

**Résultats :** Les résultats de l'atelier ont été analysés à la fois du point de vue qualitatif et du point de vue quantitatif. Les participants ont formulé des observations qualitatives très instructives sur chacun des quinze sujets traités, tant sur le plan de la façon dont ils définissent ces sujets que sur celui des questions à l'intérieur de chaque domaine qui sont pertinentes pour leurs organisations respectives. Ils ont également fait part de questions de recherche potentielles pour les futurs

travaux de recherche et développement. Les résultats quantitatifs obtenus sur les cotes attribuées à l'importance des sujets montrent que l'instruction par simulateur est considérée comme le secteur le plus prometteur pour la recherche future, suivie des caractéristiques des instructeurs, de l'apprentissage en collaboration, de l'apprentissage à distance et de l'instruction par ordinateur. Toutefois, les cotes relatives à l'importance de tous les sujets étaient très serrées. De plus, même le sujet qui avait reçu la cote la plus basse, soit l'établissement du calendrier de la formation, avait une cote supérieure au point central de l'échelle de cotation, ce qui donne à penser que les participants considéraient que les quinze sujets étaient pertinents et dignes de faire l'objet de travaux de recherche.

**Perspectives :** Ces renseignements serviront aux projets futurs en matière de recherche et de développement.

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# 1 Introduction

## 1.1 Background

Defence Research and Development Canada (DRDC) Toronto and the Canadian Defence Academy (CDA) have embarked upon a collaborative research effort to identify the most promising topics for Research and Development (R&D) on Accelerating Learning and maximizing knowledge/skill retention that could yield the greatest benefit to the Canadian Forces (CF) within five years. HSI® has undertaken this scoping study to support DRDC Toronto and CDA in achieving this objective. Follow-on R&D activities (including possible Applied Research Projects or ARPs) will be generated from the findings of the scoping study.

Accelerated learning is defined as occurring when there is "more learned in fixed time (resources) or less time (resources) to reach fixed level of learning" (Statement of Work, 2010). In other words, accelerated learning allows a shortened timeframe for learning with a comparative amount of material learned and retained. Accelerated learning is of particular importance to the military because with appropriate development and integration training can aid personnel to "quickly and effectively gain the competence required for their deployment or to retain the skills they have mastered…" (Andrews & Fitzgerald, 2010, p.4).

## 1.2 Scope and Objectives

This report represents the deliverable of this project and details the methods and findings of a literature review and workshop on accelerated learning and retention. The goal of the literature review was to generate a comprehensive list of potential research concepts related to accelerated learning and retention that DRDC Toronto and CDA may want to pursue in future R&D efforts. These concepts served as the basis for workshop discussions. Specifically, the literature review served to: (1) identify the physical, psychological and social factors that could positively or negatively affect learning rate and retention; and (2) provide preliminary recommendations for R&D that could yield the best value for the CF. In the workshop, the list of potential research topics identified through the literature review were examined by experts in the field and rated according to established criteria, culminating in a short list of topics available for further research.

## 1.3 Outline

The report is divided into 4 main sections. The next section outlines the methods and findings of a literature review while Section 3 details the workshop methods and results. The final section conveys overall conclusions.

# 2 Literature Review

## 2.1 Method

### 2.1.1 General Approach

For this literature review, we used what can be described as a "funnelling" approach. We identified many concepts and then selected the most promising concepts to recommend for future R&D. As such, the project began by broadly exploring trends, issues and factors that have shown promise to improve education, learning, training and retention. To begin, the project team identified key words pertaining to accelerated learning and retention to be used in the literature search. Selected databases were then searched using those terms. Articles were gathered based on their relevance. From this list of articles, 26 were selected and reviewed. The literature was then used to generate a list of potential research topics.

This section details the initial stages of this project leading up to the identification of concepts and topics within the accelerated learning and retention literature. The searches were geared to include all different types of skills. As a result, the body of literature examined included more complex cognitive skills as well as procedural skills and motor skills. The approach was to examine the vast literature broadly looking at both academic and public sources. The following sections outline the specific keywords, databases, selection of articles, articles reviewed and a summary of results.

### 2.1.2 Keywords

To begin, a keyword list was generated. This process involved a brainstorming session with all members of the research team, and relied on their cumulative knowledge and experience with the pertinent scientific and military domains. Feedback was provided by the scientific authority (SA) and technical authority (TA) and a final list of keywords was developed to focus the literature search. The team established a number of core concepts, which included accelerated learning, skill retention, and knowledge retention (Table 1)

*Table 1 Keywords*

| Core Concept | Primary Keywords | Secondary Keywords |
|---|---|---|
| Accelerated learning | Learn* | Acqui*, knowledge, study |
| | Accelerate* | Speed, rate, quick, fast*, expedit* |
| Skill/Knowledge Retention | Retention | Fading, retain, re-train, refresher, recogni* |
| | Training | Transfer of, transf* education, learning application, teach*, instruct*, simulation, experiential |
| | Challenges | Obstacles, ineffective*, problems, opportunit* |
| | Improve | Novel, promising, trend*, improve*, performance, |

| | | |
|---|---|---|
| | | enhance, next generation, effective*, advance*, potential, better |
| | Domain | Military, NASA, medical, higher educ*, post-secondary, corporate, emergency, police, fire fighting, search and rescue |

In a teleconference held with the HSI® team and the project TA, it was decided that all core concepts would be searched in relevant databases. In order to narrow the search when required, core concepts and/or primary key words were used. Secondary keywords were intended to provide further narrowing if necessary, however, they were not always required.

### 2.1.3 Databases

The keywords were used to search a number of databases (Table 2) with the goal of identifying review articles and empirical studies in high quality journals. Second, other media sources (e.g. The New York Times, Maclean's, educational organizations, and additional sources identified in the preliminary research stage) were searched using the keywords identified. Finally, RSS (Really Simple Syndication) feeds for search results using different combinations of these keywords were set up and reviewed daily by the project team to further identify relevant sources and key search terms.

*Table 2 Databases Searched*

| **Database / Resource** |
|---|
| Annual Review of Psychology |
| Psychology Bulletin (included under APA search) |
| APA (reviews only; journal articles) |
| Scientific America |
| Maclean's |
| Accelerated Learning workshop (D. Andrews) |
| NRC (National Research Council) |
| PsychINFO - included in APA |
| NTIS / CISTI (National Technical Information Service/ Canadian Institute for Scientific and Technical Information) |
| STINET (Scientific and Technical Information Network) |
| Google Scholar |
| TED Talks (Technology, Entertainment, Design) |
| Journal of Educational Computing Research |
| Contemporary Educational Psychology |
| Metacognition and Learning |
| Handbook of Educational Psychology (searched within 2nd Ed. 2007) |
| New York Times : Education |
| ARI (Army Research Institute) |
| The Economist |
| West Point |
| Harvard educational publishing group |
| **Conferences** |
| TEKL (Technologically externalized knowledge and learning) |
| **Others** |
| Psychological Review (included in APA) |
| Journal of Educational Psychology (included in APA) |
| Defence Research Reports Database |
| HSI technical and contract reports |

### 2.1.4 Review of Articles

After the article selection process was complete, an initial set of articles was reviewed by the research team at HSI®.

### 2.1.5 Limitations of the Review

The primary limitation of the review is that it covers a very limited number of articles, relative to the breadth of the problem space. As will be discussed in the review, the relevant literature is also relatively underdeveloped in some areas, particularly with respect to accelerated learning.

## 2.2 Introduction to Accelerated Learning

This chapter explores the concept of accelerated learning, in terms of its definition, and the alleged effects. The sections that follow address the retention of accelerated learning, and research themes and questions relevant to the concept of accelerated learning.

### 2.2.1 Definition

This review focuses on literature relevant to accelerated learning, defined as "more learned in fixed time (resources) or less time (resources) to reach fixed level of learning" (Statement of Work, 2010). In other words, accelerated learning requires the typical timeframe for learning to be shortened (e.g., 4 to 10 weeks versus 16 to 20 weeks in a traditional college course), participating in fewer learning hours (e.g., 20-32 hours versus a traditional 48-60 hours in a typical college course), with a comparative amount of material learned and retained. This can sometimes be confused with compressed courses, typically found in distance education, where learning is intensified. Students are required to spend the same amount of time learning (40-45 hours) in a shorter amount of frame (typically 6-8 weeks) (see Capuzzi Simon, 2007).

Andrews and Fitzgerald (2010, p. 26) describe the result of accelerated learning as "the attainment of competence". This definition clarifies that the goal of accelerated learning is simply to promote higher levels of competence in whatever skill area is required. However, it should be noted that they focus on accelerated learning from the perspective of complex rather than mundane skills.

The goals of accelerated learning are explicit in work by Andrews and Fitzgerald (2010, p. 20). Specifically, these goals are:

- Speed knowledge acquisition and increase duration and quantity of retention
- Cultivate deeper learning and expertise
- Acquisition of a robust knowledge/skill base
- Generalizability to similar tasks
- Retention of complex skills

Andrews and Fitzgerald (2010, p. 21) also present a number of core principles that they argue underlie the current understanding of accelerated learning. They argue that simple routine practice is not enough to promote accelerated learning, and they offer the following guidelines:

- Skills must be constantly stretched, with increasing challenges
- High internal motivation is required to promote persistence on hard tasks
- Rich, meaningful feedback is an important aspect of practice,
- Mentoring is a critical aspect of practice
- Providing for the unique learning styles of individuals through individualized or tailored practice is necessary

### 2.2.2 Effects of Accelerated Learning

The concept of accelerated learning has been a "hot topic" in learning since 1991 (Erickson, 1991). Accelerated learning can be defined as any instance in which the outcome is a level of learning or proficiency that has occurred in less time than traditionally or previously required. Such resource savings have made accelerated learning an attractive concept to industry, academia, individuals, and the military. Well-known companies, such as Shell Oil, General Motors (Erickson, 1991), American Airlines, and Kodak (Meier, 2000) have used accelerated learning in training programs. Table 3 provides concrete examples of some of the results offered by approaches intended to promote accelerated learning.

*Table 3 Examples of accelerated learning outcomes in organizations (Meier, 2000, p. xxix)*

| Company | Application | Results |
|---|---|---|
| American Airlines | Reservationists Training | Reduced training time for a lesson by 50%. Improved the retention significantly. |
| Verizon | Customer Service Rep | Cut training time in half while improving measurable performance. |
| Chevron | Fire Extinguisher Training | Reduced training time by 50% while achieving same or better learning. |
| Consolidated Edison | Cable Splicing Course | Passing rate increased from 30% to 100% in same time. |
| Commonwealth Edison | Time Keeper Training | Cut class time in half while greatly improving test scores, long-term retention and student evaluations. |
| Florida Community | Lotus 1-2-3 Course | Students learned 75% faster while enjoying the training much more. |
| Fortune 100 Midwest Manufacturer | Inventory Management Course | Reduced training time by 60% while improving learning. |
| Kodak | Electronics Course | Cut training time by a third and improved long-term retention by 25%. |
| Major U.S. Semiconductor | Hazcom and Safety Training | Improved measurable learning by 5x in the same time frame. |
| Verizon | Telephone Skills Training | Cut training time by 50% and doubled the learning. |
| Travellers Insurance | Medical Claim Benefits Training | Cut training time by 20% improving test scores by almost 5x. |

| Company | Application | Results |
|---|---|---|
| Major Retail Chain | Coaching Skills for Managers | Reduced training time by 75% while achieving better results. |

In conclusion, a number of positive accelerated learning outcomes have been noted in the literature. However, it is important to explore the factors that might underlie these outcomes. The following sections explore specific sets of factors noted within the relevant learning and retention literature as contributing to positive learning outcomes. These include student attributes, instructor attributes, delivery media, delivery methods, and skills and knowledge retention.

## 2.3 Student Attributes

This section considers the available literature relevant to attributes of the student that have been argued to impact on learning and (to the extent possible) accelerated learning.

### 2.3.1 Cognitive Ability

Cognitive ability is often identified in the literature as increasing the rate at which information is acquired. Cognitive ability is typically defined as general intelligence (or *g*) (e.g., Salas & Cannon-Bowers, 2001).

There is very good evidence in the literature that individuals with better cognitive ability tend to learn at a faster rate, thereby achieving a higher overall level of learning within the same training duration. A consistent pattern of results about the power of cognitive ability is aptly summed by Salas and Cannon-Bowers (2001, p. 478), who note "Clearly, those who have high cognitive ability (all other things being equal) will likely learn more and succeed in training". Research by Blume, Ford, Baldwin, and Huang (2010) suggests that the ability to learn better as the result of cognitive ability may carry over to being able to actually transfer work skills. For example, based on their meta-analysis of the transfer of training literature, Blume et al. (2010) found that the student characteristic most strongly related to training transfer was cognitive ability, and it showed a moderate ($r = .37$) correlation with transfer. However, an important gap identified by Salas and Cannon-Bowers (2001) is research exploring students with lower cognitive ability, and how learning can be optimized for them. They also argue that understanding the interaction between cognitive aptitude and the nature of specific jobs or tasks is another area also in need of further attention.

Two other specific forms of cognitive ability are evident in the literature. Hoffman, Feltovich, Fiore, Klein, and Ziebell (2009) note the importance of cognitive flexibility and cognitive transformation. When confronted with complex decisions, learners often use simplistic constructions of the problem that do not capture the complexity of counterarguments (or alternative ways of thinking). These constructions are called knowledge shields. Cognitive flexibility is defined as being "willing and able to recognize and overcome the knowledge shields" (Hoffman et al., 2009, p. 19). Cognitive transformation, they argue, is a closely related concept, that emphasizes the importance of unlearning. Like cognitive flexibility, cognitive transformation allows people to move beyond simplistic mental models to achieve deep understanding.

Although it has different nuances in the available literature, cognitive ability has a strong impact on student learning.

### 2.3.2 Motivation

Another major factor related to the effectiveness of accelerated training is motivation. A definition of training motivation in the literature conceptualizes it as "…the direction, effort, intensity and persistence that trainees apply to learning-oriented activities before, during and after training (Kanfer, 1991,Tannenbaum & Yukl, 1992; cited in Salas & Cannon-Bowers, 2001, p. 479).

A review of the literature by Salas and Cannon-Bowers (2001, p. 479) concluded that there was very good evidence of the power of motivation to learn "on their skill acquisition, retention and willingness to apply the newly acquired knowledge, skill, and abilities on the job". However, they also argue that strong theoretical frameworks are rare. In one notable example of such a model, Colquitt, LePine, and Noe (2000) presented and tested an integrated model of training motivation. This model is consistent with many factors identified in other models of transfer (e.g., Baldwin, Ford, & Blume, 2009). These include student attributes, the work environment, and a wide range of near and far transfer outputs (e.g., declarative knowledge and reactions, and job performance). Results of their analyses showed that the four learning outcomes (declarative knowledge, skill acquisition, post-training self-efficacy, reactions) explained about half of the variance in transfer. However, when more distal variables (personality, age, situational variables) were included, a total of 81% of the variance in transfer could be explained. These results support the assertion that individual attributes along with relevant situational variables do have a direct impact on the transfer of training in the workplace, over and above what students take away from the training session (as measured by the learning outcomes). This research shows good evidence of the importance of individual attributes such as motivation, even independently of training approaches.

The role of motivation is also notable in the literature specifically addressing accelerated learning. Motivating students to learn comes directly from the founding principles and assumptions of accelerated learning. Meier (2000) argues that accelerated learning requires hard work, it requires students to be actively involved with their whole mind and body, and learning should consist of "creating" rather than consumption. High levels of motivation are necessary for effective learning and lead to more favourable outcomes, (see Andrews & Fitzgerald, 2010; Baldwin et al., 2009; Cannon-Bowers & Bowers, 2008; Meier, 2000; Zipperer, Klein, Fitzgerald, Kinnison & Graham, 2003). When every minute counts (as is the case in accelerated programs), motivation is of critical importance. This is one reason why training interventions aimed to increase student motivation such as gaming, team activities (e.g., games, brain storming), web-based discussion, virtual worlds are used to promote learning (see Cannon-Bowers & Bowers, 2008; Erickson, 1991; Meier, 2000). Students who are fully engaged and motivated to learn actually acquire more information and are able to retain it longer (see Andrew & Fitzgerald, 2010; Meier, 2000). Students who have high motivation take ownership of their own learning, become more engaged, and get more out of the experience (see Cannon-Bowers & Bowers, 2008; Meier, 2000). Exercises such as goal setting and encouraging goal commitment increase ownership of learning which is associated with effective learning (Schunk & Ertmer, 1999; cited in Cannon-Bowers & Bowers, 2008). This literature suggests that highly motivated students may be necessary for accelerated learning to occur.

A potentially important aspect of motivation for some learners is the need to see and understand the relevance of training efforts. Skills and theory can help military members understand not only what tasks need to be done and how they need to be done, but also why they need to be done. Understanding the relevance of training can also help learners to increase motivation, focus, and recognize when and how specific skills should be applied (see Zipperer et al., 2003).

Whatever the focus, then, the motivation of the student has a consistently strong impact on learning.

### 2.3.3 Learning Styles

Learning styles is defined in the literature as "…the view that different people learn information in different ways" (Pashler, McDaniel, Rohrer, & Bjork, 2008. p. 106). The available literature suggests general endorsement of the importance of learning styles. For example, researchers argue that preferred learning styles vary between students, and personalized instruction can capitalize on these differences to enhance learning for the individual (Andrew & Fitzgerald, 2010; Cannon-Bowers & Bowers, 2008). Students find learning more exciting, easier, and consequently are more motivated when they are coupled with their unique learning style (see Andrew & Fitzgerald, 2010; Meier, 2000). Unique attributes of the individual and preferred learning styles of the student can call for learner-centered instruction. Meier (2000) argues that accelerated learning is the human factors approach that brings the student into the center of learning which is a divergence from the traditional "cookie cutter", lecture-style, "one size fits all" teaching approach prevalent in western society. Interestingly, Pashler et al. (2008) argue that although people clearly express preferences about their own learning styles there is little evidence that different people actually benefit from different teaching styles (e.g., "visual" versus "verbal"). This suggests that what people prefer when learning is not necessarily what helps them learn better.

Pashler et al. (2008) identify the "meshing hypothesis" as a common hypothesis relevant to learning styles. According to this hypothesis, providing training and education in formats that match the preferences of a learner (e.g., using visual information for a visual learner) will maximize learning effectiveness. However, research by Pashler et al. (2008) specifically focused on the validity of the meshing hypothesis. They argue that understanding the impact of learning styles requires carefully designed experiments that control for potential confounds. For example, students would need to be divided into groups based on their learning styles, and the groups would be randomly selected to receive a specific instructional method. Credible evidence for the true impact of learning styles would be an interaction between learning styles and instructional methods, such that learners with varying styles would be differentially affected by different instructional methods. Pashler et al. (2008) argue that such controlled experiment research is rare, and that the research that has been done contradicts the meshing hypothesis. Given the lack of strong empirical evidence Pashler et al. (2008) argue that the widespread acceptance of learning styles as a critical factor to consider in designing training may be premature. They conclude that "there is no adequate evidence base to justify incorporating learning-styles assessments into general educational practice" (Pashler et al., 2008. p. 105). On the other hand, this lack of evidence does not mean that learning styles do not exert some impact – merely that the importance of learning styles has not been scientifically proven.

In summary, although there is implicit agreement about the importance of learning styles, the relevance of learning styles remains in need of future research and development.

### 2.3.4 Prior Knowledge or Experience

Prior knowledge and experience is also noted in the literature to impact on skill acquisition. Prior knowledge relevant to a task or skill (e.g., previous training and education) provides a foundation on which to build skills which can lead to quicker and more effective learning and longer retention. Goodwin (2006) reviewed several reports that indicated computer background knowledge has an impact on training and retention of digital skills. As expected, individuals with greater knowledge can more easily organize and encode new information, as it is more likely to fit into existing schemas (Goodwin, 2006). In addition, exposure to more classroom instruction where systems are explained may facilitate learning of procedural skills. The theoretical background may consequently improve performance.

It is important to point out that prior knowledge and experience do not necessarily lead to consistently positive impacts on learning. For example, dissimilar skills can create interference or negative transfer when attempting to learn new or related skills (Rowatt & Shlechter, 1993). Moreover, prior negative experiences during learning can also adversely affect learning and retention (Smith-Jentsch, Jentsch & Payne, 1996; cited in Salas and Cannon-Bowers, 2001).

One notable type of prior experience or knowledge that is important to highlight is comfort with technology. Level of comfort with technology is noted in the literature as impacting on ability to learn and perhaps even the motivation to learn (Capuzzi Simon, 2007; Zipperer et al., 2003). In this sense, students' negative previous experiences attempting to use unyielding technology could hinder the ability to learn in a new situation.

### 2.3.5 Other Student Attributes

Several other themes emerged from our review of the literature as relevant student attributes that might impact on their learning.

One key characteristic likely to influence the ability to achieve accelerated learning is expertise. Expertise has been argued (Hoffman, 1996; cited in Andrews and Fitzgerald, 2010) to have 3 key dimensions. First, the development of expertise is the result of deliberate and persistent practice in relevant and diverse tasks, rather than being the result of simple maturation. This means that only people who are sufficiently practiced can hope to have expertise. Within the available literature (e.g., Hoffman et al., 2009), some researchers estimate that true expertise takes about 10 years to develop. Second, expertise is commonly understood as requiring a distinct set of knowledge structures. These structures are highly abstract and reflect deep understanding of complex relationships among the various elements. These elements are organized in ways that are meaningful to the expert. Lastly, because of these rich knowledge structures, experts are also able to anticipate potential problems more effectively and to solve problems that emerge more adeptly as well. Their rich knowledge allows them to attend more efficiently to critical information and to filter out extraneous information better than novices, and they are able to perform well under levels of high stress and workload (Hoffman et al., 2009).

Researchers interested in accelerated learning specifically focused on expertise in order to create programs that shorten the gap between novice and expert performance. Experts with a deeper understanding of a task seem to efficiently and effectively organize information into mental models. The mental models of experts are more abstract than the models of novices, whose mental models tend to focus on surface features developed from superficial understanding of the tasks (Glaser, 1989; cited in Cannon-Bowers & Bowers, 2008; Schumacher & Czerwinski, 1992 cited in Andrews & Fitzgerald, 2010; see also Collard, Gelaes, Vanbelle, Bredart, Defraigne, Boniver et al., 2009).

The metacognitive abilities of students also emerged from our review of the literature. Metacognition is defined by Ford, Smith, Weissbein, Gully, and Salas (1998) as the degree to which an individual is aware of and in control of his or her cognitions. The ability of individuals to be knowledgeable about their own styles of learning (and to be able to adjust their efforts accordingly) is a key aspect of learning. Unfortunately, this issue received passing mention rather than discrete coverage in the limited number of articles sampled. For example, some researchers noted that reflection on performance can be used to gain insight into errors and corrective behaviour (Fu et al., 2009)

Self-efficacy is another construct that has been widely studied in relation to learning and skill acquisition. Self-efficacy is defined as the "belief that one can perform specific tasks and behaviours" (Salas & Cannon-Bowers, 2001, p. 478). The power of self-efficacy is summarized in a review by Salas and Cannon-Bowers (2001, p. 478) who argue "whether one has it before or acquires it during training, leads to better learning and performance". Self-efficacy is another characteristic of students that will impact on their learning.

Some research noted in the available literature also indicates that a students' level of working memory is another important individual difference factor (Dyer and Salter, 2001; cited in Goodwin, 2006). This research showed that presenting digital training by deliberately varying levels of demand on working memory (in either large chunks with 9 to 18 pieces of information, or small chunks in 3 to 9 pieces of information) had significant impact on training effectiveness. Using lessons with small blocks of information was more effective. This empirical study suggests that attending to the capacity limitations of working memory may be important to promote learning.

### 2.3.6 Emerging Research Themes and Questions – Student Attributes

Many student attributes are likely to impact on their ability to learn information and to retain it. This section shows that cognitive ability, motivation, learning styles and prior knowledge and experience are key factors argued to impact on the ability to learn and to benefit from training. Many individual attributes are generally less amenable to change. Although the motivation to learn is not necessary a stable trait, for example, cognitive ability is relatively set within boundary conditions.

One of the problems with this area of research, however, is that it lacks a strong theoretical base, and there is little evidence of truly integrative approaches that consider the role of individual factors as a whole. Most of the current literature is limited to very few factors. This area of research also lacks meta-analytic efforts that would help provide critical information about which of the factors within this area are actually the most critical. At best, within most of the literature

reviewed in this report, individual differences are most often considered in interactions with other variables, such as training variables. This makes it difficult to understand the pure and distinct impact of attributes of the individual.

Perhaps even more critically, understanding the impact of individual attributes relative to other sets of factors (such as the impact of varying delivery media) is also impossible given the available literature. This means that if research and development efforts must target the most critical questions with the most promise of "payoffs" within a relatively short period of time, it would be ideal to be able to make a strong statement about how important individual differences really are. This is a gap in the current literature that may need to be addressed.

Based on the available literature, the two individual differences that seem particularly important are cognitive ability and motivation of the learner/student. This opinion is based on the dominance of cognitive ability as a factor throughout the reviewed literature, as well as the consistent prominence of motivation. Motivation showed good presence in the literature as well as being supported by substantial empirical evidence. Given the relatively stable nature of cognitive ability, of course, the focus would have to be on how to help learners with varying levels of cognitive ability to make the most out of their capacity. The impact of motivation on learning appears to offer a rich set of research questions that could be explored. Given that motivation appears to have a serious impact on how (and whether) individuals learn, the obvious question is whether increasing motivation can help to accelerate learning. However, the role of motivation as an interactive effect (rather than as a main effect) may be more fruitful, as the literature is strongest when motivation occurs in combination with other variables.

The potential role of motivation in supporting positive training outcomes is also worthy of future exploration. One of the possible stumbling blocks for trainers is that training can be arduous and even boring for students. Given the non-voluntary nature of some of the training undertaken within a military system such as the CF, an important question is whether motivation can be meaningfully enhanced or maintained through the construction of instruction techniques targeting student engagement and involvement. This is true in terms of the impact that the emergent training technologies could have on motivation. Understanding how to use technology to provide the learner with a sense of involvement and empowerment would be important contributions that could have a significant impact on learning. A key issue for future research and development to explore is whether the effectiveness of training can be meaningfully affected by systematic attention to tools and technologies that promote learner motivation.

The research reviewed in this section shows that the unique attributes of individuals have a clear impact on the ability to learn. Clear and unequivocal information about the boundary conditions of individual attributes in a range of training environments and given a range of diverse tasks would be helpful. Specific findings and possible research questions are shown in Table 4.

*Table 4 Findings and Research Questions- Student Attributes*

| | |
|---|---|
| **Student Attributes** | |
| Student attributes impact on learning | What student attributes are most critical to learning?<br>What is the relative importance of student attributes relative to other sets of factors (e.g., delivery media)? |
| Cognitive ability promotes learning (Salas & | How can learning be optimized for individuals with low cognitive |

| | |
|---|---|
| Cannon-Bowers, 2001) | abilities? |
| High motivation to learn increases learning (Blume, Ford, Baldwin, & Huang, 2010; Meier, 2000).<br>Hands-on experience can increase motivation.<br>Understanding relevance of training can increase motivation to learn application of newly learned skills. (TLC, 2010; Zipperer, Klein, Fitzgerald, Kinnison, & Graham, 2003). | How can training be designed to maximize student motivation? What approaches and technologies (e.g. virtual worlds) best promote immersion, engagement, social presence, how best to promote "flow"<br>Embodiment, presentation and engagement (physical representation of the user, e.g., fidelity of the avatar) |
| Learning styles may influence learning | Should learning styles be further investigated? |
| Prior knowledge or experience can improve learning (e.g., computer background knowledge has an impact on training and retention of digital skills (Goodwin, 2006). | How can prior knowledge and experience be brought to bear on training effectiveness? |
| Level of comfort with technology can slow or increase learning and motivation to learn when using technological tools (Capuzzi Simon, 2007; Zipperer et al., 2003)Expertise improves learning (Andrews & Fitzgerald, 2010) | How does experience and comfort with technology impact on learners in technology-based training? What compensatory approaches might support personnel with low levels of experience?<br>How can training build expertise more quickly?<br>How can expertise best be leveraged?<br>Can emerging technologies support the emergence of expertise? |

## 2.4 Instructor Attributes

Instructors have a key role to play in training. Instructors are obviously very diverse, and factors such as their subject matter expertise, their experience as a teacher and their style of teaching emerged from the literature review as important instructor attributes. Within the work environment, a meta-analysis by Blume et al. (2010) found that support (peer and supervisor) was the most influential factor on transfer of training. Instructors, then, have a potentially critical role in promoting learning and training effectiveness.

Many training programs use experts to provide instruction to students; military programs have also taken this approach (Zipperer et al., 2003). Learning from high performing training specialists who know the material in question and can effectively provide instruction may be "more important than ever" if the goal is to promote a high degree of learning and retention (Zipperer et al., 2003, p. 22). However, one potential downside to using experts to present training is that their subject matter expertise does not necessarily make them good instructors. Experience as an instructor is another important variable to consider. The motivation of an instructor to teach is another possible influence on the effectiveness of learning.

The role of mentors in promoting learning is also relevant to this discuss. A mentor may or may not be an instructor, but they share some of the role of instructors, namely to help promote the learning of students or peers. Hoffman et al. (2009) identify several attributes of a good mentor, as follows:

- Able to create appropriate content for the learner
- Able to form a mental model of the learner's knowledge and skill
- Able to anticipate probable errors, and to tailor exercises accordingly

Although these attributes are most easily applied when the mentor is a human instructor, these attributes are also requirements that must be met by intelligent systems that are specifically designed to challenge the learner.

In sum, the role of the instructor requires a combination of delegation, support, and coaching that is matched to student commitment and capability related to the task at hand.

### 2.4.1 Emerging Research Themes and Questions – Instructor Attributes

The instructor has also been identified as a key element in training effectiveness. The issue of how instructors within the CF training system can be most effective would be an important issue for future research and development. Within the CF training system, instructors come from all levels and specialties, and the level of their qualifications as subject matter experts and instructors varies widely. An important issue for future research and development efforts would be exploration of the impact of varying levels of instructor expertise and experience as instructors. A number of sample research questions that could focus this research are provided in Table 5.

*Table 5 Findings and Research Questions- Instructor Attributes*

| **Instructor Attributes** | |
|---|---|
| Instructor attributes (e.g., subject matter expertise, teaching experience and teaching style) impact on learning | What are the most critical aspects of instructor effectiveness?<br>What is the ideal mix of subject matter expertise and teaching experience?<br>What makes a good mentor? |

## 2.5 Delivery media

Advancements in technology over the past 20 years have yielded a range of literature and research aimed at improving learning and retention through the use and implementation of technology in training. Technology may be particularly useful in circumstances where time resources are limited and brief episodes of skill performance can provide some form of practice that will help to retain competency (Andrews & Fitzgerald, 2010). This section describes various delivery media identified in the literature review.

### 2.5.1 Classroom Aids and Environment

#### 2.5.1.1 Conventional Classroom Instruction

Conventional classroom instruction has been the dominant way to promote learning and retention. Stereotypic classrooms consist of an instructor, students and typical means of classroom instruction include blackboards and other media devices. There are obvious many different methods and approaches related to the conduct of classroom construction. For example (Goodwin, 2006, p. 5) cites the work of Clark and Wittrock (2000), who conceptualized training in terms of digital or non-digital and the continuum of instruction as ranging “from external

(instruction is driven by environmental factors) to internal (driven by factors internal to the learner)". Four types of training along this continuum are:

- Receptive (teaching by telling)
- Behavioural (teaching by demonstration, practice and feedback)
- Guided discovery (teaching by problem solving)
- Exploratory (teaching by exploration)

Interestingly, Clark and Wittrock (2000; cited in Goodwin, 2006) argue that there may be no uniformly best approach, but that this depends on the best match for the individual. For example, they argue that receptive approaches may be best for novices, but that experts with the motivation and metacognitive awareness may do better with exploratory approaches.

In general, there is some evidence that training that consists only of receptive style of instruction may not be optimal. Lecture-based instruction is argued to be less favourable by many students (Schaab & Dressel, 2001) and ineffective in terms of accelerating learning (Meier, 2000). Other exploratory techniques that provide experiential learning have been argued to support accelerated learning (Meier, 2000). In the end, the most effective type of instruction may depend on the training content, student attributes, and available resources.

#### 2.5.1.2 Learning Environments

Creating a positive learning environment is essential in accelerated learning (Meier, 2000). Accelerated learning is more likely to occur within an enjoyable training environment. A positive learning environment is argued to increase learning and makes accelerated programs more efficient (Meier, 2000).

In a short report, Training & Leadership Coaching (TLC) (2010) emphasized that a warm, welcoming, comfortable environment was most effective in fostering learning. Positive learning environments can be achieved through attention to physical and psychological elements.

The physical aspects of a room, the layout, lighting, views from the window, access to fresh air, and space to move around are important aspects of a comfortable learning environment and should be considered in part of the planning process of a training program.

Engaging all five senses and involving students in different activities that make the learning experience enjoyable while reinforcing content is the foundation of accelerated learning (Meier 2000; TLC, 2010). Meier (2000) detailed the importance of engaging the learner through auditory (e.g., playing music, engaging in discussion, reading aloud), visual (e.g., skits, video, images), kinaesthetic (e.g., active games, field trips, performing tasks), and olfactory/gustatory techniques (e.g., aroma therapy, extinguishing negative aromas, pairing an aroma or flavour with learning). The justification for stimulating multiple senses in such a way is that students learn more when fully immersed. We learn more French when in France, fully surrounded by French language and culture including music, signs, smells, and food (Meier, 2000). Another example described by Erickson (1991) showed that playing music during training or during breaks increased students' moods resulting in better learning and retention. Caution is also advised in over-use or inappropriate use of music. For example, different tastes in music may make a learning

environment unfavourable to some, and music should not be used unless all students agree on the music to be played. From a training perspective, the key is that instructors should actively think about the impact of adding sense-stimulators to the learning environment. They should be applied with caution and if something is attempted that does not provide the desired effects, it should be stopped or altered.

In contrast to a focus on the physical environment, psychological components of the environment also impact learning. Learning culture (or similarly, transfer climate) is the sum of attitudes, values, and norms that stem from supervisory and peer support, task cues, training accountability, opportunities to practice, opportunities to use new knowledge and skills, and intrinsic and extrinsic rewards for application of knowledge (see Aguinis & Kraiger, 2009). A recent meta-analysis by Blume et al. (2010) shows the importance of the work climate as an impact on transfer of training. This review showed transfer climate as being moderately correlated with transfer. However, Aguinis & Kraiger (2009) have argued that research relevant to transfer, as a whole, is mixed and inconsistent. They reviewed studies showing both positive (e.g., Richman and Hirsch, 2001; cited in Aguinis & Kraiger, 2009) and null effects (e.g., van der Klink et al., 2001; cited in Aguinis & Kraiger, 2009) related to positive transfer climate.

Although this area of research has some mixed results, there is agreement in the literature about the importance of positive learning environments.

#### 2.5.1.3 Classroom Aids

Several classroom aids that can be used to promote learning also emerged from the literature. Classroom aids are identified as an activity based tools or technique. Those described in the literature include:

- Concept mapping (e.g., Panel and flow drawings)
- Opportunity training
- In-class tools and techniques (e.g., audio tape piping and instrumentation , or P & ID, Crossword puzzles)

*Concept mapping*

Concept maps or “mind maps” can be used to form explicit knowledge frameworks of new information (Erickson, 1991). Expert mental models are more abstract than those of novices. Making mental models explicit through tools such as mind maps are argued to promote learning and advance expertise (Erickson, 1991). Creating drawings of mental models can accelerate learning through promoting both differentiated and integrated organization of the material being learned. Besides mind maps, concept maps can be displayed as panel and flow drawings, placards, posters, or flipcharts that can be developed by students during a learning program and later used as a resource to reflect on the material learned (Erickson, 1991). Mental models can be developed and reminders of learned material may serve to ‘refresh’ the learned material.

Concept mapping techniques or tools can be implemented differently depending on the context, course material, student and instructor preferences, and available resources. Techniques should be selected and implemented based on the intended goal. For example, mind maps have been found to be effective in forming explicit knowledge networks of information. Mind maps may be

preferable in circumstances where the goal is to help students learn and practice how to develop mental models.

*Opportunity training*

Opportunity training is one way to maximize time efficiency, learning, and retention that are fundamental in military training (see Erickson, 1991 and Zipperer et al., 2003). A recent review investigated training techniques useful within military training, specifically instruction of dismount combatants and small units (Zipperer et al., 2003). A relevant technique identified was "opportunity training" or "hip-pocket" training, where instructors conducted short 15-20 minute lessons between the "cracks" of a training program (e.g., compass training during a water break while on a hike). Opportunity training can be used to decrease the hours within a training program; unfortunately, resources required for such training are not always available. Printed copies of manuals or soldier handbooks that are often used are no longer printed, or are rare and thus have limited the amount that this method is currently implemented. There was no evidence as to how much this technique has been used or whether it has been shown to be effective.

*In-class tools and techniques*

Some additional aids were noted during the literature review (Erickson, 1991), but received only limited attention, as follows:

1. Audio tape piping and instrumentation (P&ID) has been used as a method of making training unique and different helping to capture students' interest and provide motivation. Caution is advised not to overuse this technique (Erickson, 1991).
2. Crossword puzzles are an activity that can provide a fun method of learning, maintain student's interest and accelerate learning (see Erickson, 1991).
3. Games provide novel and/or motivating methods of learning (Erickson, 1991; Cannon-Bowers & Bowers, 2008). Technology has been used to provide gaming-based training programs and its application is expected to continue to grow in the future.

### 2.5.2 Distance Learning

Distance learning emerged from the literature review as an important delivery media. The Merriam-Webster dictionary defines distance learning as "Education that takes place via electronic linking instructors and students who are not together in a classroom". Students are often geographically separated from each other as well as from the instructor. It is possible however, to have several students co-located with a geographically distributed instructor, or to have several students and an instructor co-located while other students are geographically distributed. Industry and education are the largest sectors in society that utilize distance learning (Braddock, Berryman, Dickinson, Gerry, Hartman, et al.. 1997). Braddock et al. (1997) point out that within the educational system, distance learning courses are developed based on principles of making learning efficient and effective for students to acquire knowledge.

There are multiple ways of implementing distance learning. Braddock et al., (1997) describe three distance learning teaching modes. Distance learning can be 1) *remote* requiring synchronous

attendance by students and instructors; 2) *canned* in which case material is recorded and accessed by students individually at a convenient time for them (asynchronous); and 3) *collaborative* where students can interact through discussion boards, emails (asynchronous) and or chat (synchronous). These techniques are not necessarily mutually exclusive, and a combination of them may be optimal depending on type of skill/knowledge to be trained, resources allocated to the instructor, resources of the student, and additional responsibilities either may carry (e.g., career or family obligations).

There is some evidence in the available literature about the effectiveness of distance learning for promoting learning. A report in the New York Times details evidence from U.S. universities that shows students who enrol in a course that has a component of distance learning earn higher grades compared with those who enrol in residential courses (Capuzzi Simon, 2007). Particularly for adult education, distance learning provides flexibility and mobility needed to juggle training and education with careers and family life (Capuzzi Simon, 2007). Learner responsibility can be increased by providing students with control over tasks performed or by providing the student with control over learning such as controlling the pace of learning as is often seen in distance education or on-line courses (Cannon-Bowers & Bowers, 2008).

As technology advances, the tools available for promoting distance learning have also increased. For instance, instead of stationary desk computers, mobile (portable) technologies such as iPads are increasingly being used to promote mobile learning (m-learning). Mobile media may be effectively utilized particularly in a military environment when it may not be feasible or convenient for trainees to access computer-based instruction via computer laboratories, offices, or home-based computers. Mobile technology is also increasing the use of multimedia in both formal (classroom based) and informal (peer discussions) learning. Today's technological culture has increased the opportunities for informal learning. Having access to portable devices to communicate, play online games, search the internet, and read internet based material may provide many more opportunities to learn informally than available through formal means such as classrooms. This may be one area that requires further exploration, specifically focusing on technology and computer-based learning.

Nonetheless, distance learning is also noted as having some potential limitations. For example, distance learning restricts the level of interactivity between the student and instructor. This suggests that distance learning courses may be most effective for students who are motivated and disciplined, rather than those who require more hands-on guidance from the instructor. As noted in earlier sections, learning styles and leadership styles can affect learning.

### 2.5.3 Simulator-Based Instruction

Simulations are predominantly used to training new skills and, but some researchers have argued that they have been rarely used in refresher training (Ginzburg & Dar-El, 2000). Similarly, simulation-based research has investigated immediate performance effects and little is known about the effects on retention.

A review of the literature showed that simulator-based instruction has focused on synthetic learning environments (SLE). SLEs are technology-based applications that work to reflect real world experiences (i.e., simulations, games, and virtual worlds) which can provide unique

learning opportunities (e.g., Cannon-Bowers & Bowers, 2008). Several advantages of using SLEs for training include:

- providing a collaborative tool for geographically distributed team members,
- providing real world experiences when actual experiences are not feasible (e.g., equipment is not available), not practical (e.g., too dangerous, theatre of operation is not accessible), or infrequent (e.g., emergency procedures),
- providing feedback during or immediately after task completion,
- providing cost savings relative to training on operational equipment,
- allowing for "tremendous flexibility in manipulations of fidelity – differing kinds and amounts of contextual richness" (Hoffman et al., 2009, p. 21).

There is good evidence of the effectiveness of SLEs in education. Research has shown that using SLEs to train college or high school subjects (e.g., visual attention skills, programming skills, geology, and cell biology) increases student outcomes (see Green & Bavelier, 2003, Emurian, 2005, and McClean et al., 2001; cited in Cannon-Bowers & Bowers, 2008). Research using SLEs has demonstrated that web-presented information significantly increased test scores of students compared with those in more typical lecture (control) groups (Cannon-Bowers & Bowers, 2008).

However, one serious gap in the literature has been identified. As Cannon-Bowers and Bowers (2008, p. 318) have noted, although there has been increasing reliance in technology over the past 30 years "…some of these development efforts have been successful, others have not, and still others (the majority perhaps) are of unknown value because they have never undergone rigorous empirical testing". Moreover, they also argue that "SLEs are almost always built with an emphasis on technology, and pedagogy is often worked in as an afterthought." (2008, p. 319). Nonetheless, they argue that because of what is known about how people learn (e.g., experts tend to chunk information, and build integrated mental models to be able to do so), it is clear that SLEs should help to promote learning.

In military contexts, the use of technology for training is becoming increasingly common. The effectiveness of three technological training techniques used in an established command and control curriculum at Army's Armour School at Fort Knox, Kentucky were compared by Fu and colleagues (2009) to highlight the benefits of each approach. These techniques, live demonstration, terrain board demonstration, and virtual demonstration, were used for soldier training.

A live demonstration involving a breaching exercise (employing tactics, techniques and procedures to overcome obstacles that stop, delay, divert or restrict movement such as in a convoy), was conducted with all instructors and students present. Exercises were performed in real time and tasks were conducted by each student. A vast amount of resources were required including vehicles, fuel, and collocation of all students and instructors. Feedback was provided post hoc in After Action Reviews (AARs).

Terrain board demonstrations used PowerPoint slides to guide instruction and allow instructor facilitated discussion and collaboration (peers working together and sharing experiences) during critical reflection and discussion. In addition, soldiers were provided with the opportunity to

practice command and control tasks using a 3-D model terrain board. The ability to collectively share experiences and practice repeatedly while receiving immediate feedback from peers and instructors were highlighted as advantages.

Virtual demonstration provided a walk-through visualization of the tasks controlled by the instructor. Viewpoints (camera angle) and time (duration of the lesson) can be varied and controlled by the instructor. As a virtual tool, it can provide a lot of flexibility. Terrain can be easily and quickly switched and cross-training is possible as both the instructor and student can operate or perform tasks within the environment. Collocation is not necessary if the instructor and students are equipped with appropriate resources while geographically distributed. As a cost benefit, the lesson can be recorded and later played back for review, practice, and/or retraining.

Results showed that both the terrain board demonstration and the virtual world demonstration could be conducted in faster than real-time. Compressed training that leads to high levels of proficiency demonstrate accelerated learning. The positive performance outcomes shown in this study are evidence of the effective application of technology to accelerated learning and improve learning. A comparison summary of all three training approaches is shown in Figure 1.

| | Live Demonstration | Terrain Board Demonstration | Virtual Demonstration |
|---|---|---|---|
| **Viewing Perspective** | Real, situated, tactical | Model, 2-D bird's eye view | Both 2-D bird's eye and 3-D tactical views, either instructor- or trainee-driven |
| **Resources** | Live use of real assets | Small-scale model terrain construction | Computer-based terrain construction |
| **Scene Arrangement** | Longest, involving physical placement | Fast, requiring placement of micro armor assets | Fast, virtual world placement of assets |
| **Time Efficiency** | Real-time | Faster than real-time | Faster than real-time |
| **Shared Experience** | Yes (team – no) | Yes | Potentially yes |
| **Repeatable** | Yes, requires moving assets, role players | Yes, requires moving assets | Yes - with simulation control |
| **Stimuli** | Real life | Abstraction | Life like + abstraction |
| **Feedback** | Delayed | Immediate | Immediate with playback |
| **Team Training Capable** | Yes - limited cross-training | Yes - limited cross-training | Yes |
| **Distribution** | No - All participants must be present | No - All participants must be present | Potentially yes |

*Figure 1 Comparison of Armour School demonstration approaches (Fu et al., 2009)*

The research by Fu, et al. (2009), undertaken for the U.S. Army shows the dilemma presented by the current state of the literature, "While most will agree that live demonstrations are the most effective way to convey information to warfighters, this conjecture has never been proven" (p. 1). They argue further that demonstrations can be undertaken in typical ways or in virtual world simulations but, "what's needed is a framework that can taxonomize training demonstrations, and prescribe ways to measure the usefulness of any given demonstration" (Fu et al., 2009, p.1).

Cannon-Bowers and Bowers (2008) note the potential value of using scenarios (such as in demonstration type training), and also point out challenges noting "One of the problems with

scenario or case design is that it is typically very time consuming and requires expertise from SMEs and instructional designers. A possible solution to this challenge is to automate the development of scenarios by providing authoring tools for users; development of such tools should be a priority in future work" (Cannon-Bowers & Bowers, 2008, p. 323).

As demonstrated by Fu et al., (2009), simulations can be used to develop realistic training where learning and practice activities closely reflect real-world performance requirements (see also Zipperer et al., 2003). Simulations can be used in a manner to challenge individuals where real-world problems are introduced frequently (relative to real-time) in training. Hoffman et al. (2009) note that simulations should be constructed to intentionally mislead a student seeking solutions to specific problems.

> "People must be trained to be resilient, so that they can cope with complexity when unexpected events stretch resources and capabilities. And people must be trained faster. Intelligent systems technology, and intelligent use of technology, will certainly play a critical and perhaps necessary role in this". (Hoffman et al., 2009, p. 21).

The situations and methods in which simulation-based instruction can be used are vast. Salas and Cannon-Bowers (2001) argue that, in general, there is strong empirical evidence that simulators can be an effective tool; however they note that SLEs have not been found to be universally effective. "Precisely why simulation and simulators work is not well known. A few studies have provided preliminary data…, but there is a somewhat misleading conclusion that simulation (in and of itself) leads to learning" (Salas & Cannon-Bowers, 2001, p. 484).

Other critics have warned against potential negative effects of training using simulations as it requires individuals to spend time learning how to use simulation equipment, and often includes learning to work as a collective team (Zipperer et al., 2003). Though the latter is vital to effective team work, it takes time away from training individual skills that must be mastered in order to support the collective (Zipperer et al., 2003).

In conclusion, simulation-based instruction has been demonstrated as very useful in training. Specifically, it has been used to compress training and engage students. As noted, however, exactly why simulation is effective at promoting learning outcomes does not appear to be sufficiently well understood.

### 2.5.4 Computer-Based Instruction

This section details the nature of computer-based instruction, tools that have been implemented in such training, possible implications to the instructor, and digital skills.

Andrews and Fitzgerald (2010) point out that in order to develop accelerated learning programs, non-time resources, such as computer-based instruction, will be required. Computer-based instruction can involve a range of media from simple, non-interactive videos to highly interactive, multimedia, multi-player, collaborative gaming environments. They can also be highly structured with only one path to follow through learning material, or loosely structured allowing trainees to explore at will. With the increasing evolution of technology, the role of computer-based instruction is expanding the possibilities of training, and associated research areas.

Simplistic computer-based instruction may include videos, multiple choice activities, or single-task practice activities (e.g., typing tutor). More advanced tutoring programs can have varying levels of intelligence. Cognitive Tutoring Systems provide a technological framework which allows retrieval, practice, and provides adaptive feedback (see Andrews & Fitzgerald, 2010). The Graphical Instruction in LISP (GIL) is one such system that presents lessons and exercises as well as monitored and analysed student progress. The system provides advantages such as individualized feedback and is able to adjust lessons based on demonstrated proficiency (Bryant & Angel, 2000).

Another advantage to computer-based instruction is the ability to record trainees' progress throughout the task, such as with the intelligent tutoring systems. Baseline measures can be easily obtained and follow-on practice can focus on weak areas. Accurate targeting of weak areas for the purpose of remediation may be one method that effectively leads to accelerated learning.

Highly interactive computer-based instruction, such as gaming, can provide learning opportunities that offer more time in practicing a task, and increase motivation and engagement (Andrews & Fitzgerald, 2010). Examples of such games include Immune attack, America's Army: Special Forces, Spore, and River City (Andrews & Fitzgerald, 2010). Some research has been done that indicates that the use of gaming can lead to accelerated learning. For example, Cannon-Bowers and Bowers (2008) demonstrated that gaming-based simulations significantly increased test scores compared with control (lecture) groups. Thus, computer-based instruction that provides convenience and engagement of the learner(s) can promote positive learning outcomes.

However, there is also some evidence that this form of instruction can also have a significant impact on the instructor. Development of training programs that use computer-based instruction can substantially reduce the amount of time needed for instruction (Kulik & Kulik, 1991). Having basic assessments of performance automated within a tutoring system would also reduce some obligation on the part of the instructor to provide such assessments. However, depending on the nature of the computer-based instruction, there may be more up front work required to prepare and plan training; a responsibility that would most likely fall on the instructor. It is worth noting however, that once planned, the computer-based program may be used and reused without additional planning, thus making the upfront work cost effective in the long-run.

Digital skills are relevant to computer-based instruction. They are defined as related to the use of software on a computer, requiring some form of data entry through a graphical user interface (GUI) (Goodwin, 2006), and they range from being relatively procedural in nature (e.g., clicking a button) to managing highly complex systems (e.g., using multiple digital systems for battlefield command and control). Training digital skills will be an important part of training as instruction and learning become increasingly computer-based. Research by Goodwin (2006) identifies several patterns evident in the literature relevant to the effectiveness of digital training. First, he argues that unguided exploration is the least effective way to train digital skills. Second, digital training that uses at least some form of behavioural modelling (with either live or videotaped demonstrator) is more effective than a fully computerized tutorial. However, this pattern of results is true for acquisition, but not retention. Lastly, Goodwin (2006) argues that guided exploration (e.g., minimal instruction followed by working through exercises) is more effective than unguided exploration, behavioural modelling, computerized tutorials, or classroom instruction alone. However, research also shows that constructivist techniques that combine guided exploration and

behavioural modelling can be a potent combination for teaching digital skills (Goodwin, 2006). Future research in the area of computer-based instruction may also need to consider the impact of digital skill on knowledge/skill training.

Building on the requirement to have adequate digital skills for computer-based instruction, individuals must also have an acceptable level of comfort with technology. Cannon-Bowers and Bowers (2008) noted that negative emotions and anxiety associated with computer or technology use can severely interfere with learning. This can be an issue when using new or complicated technology, especially when immediate assistance with technology may not be available (e.g., as may occur with distance education - see Capuzzi & Simon, 2007).

### 2.5.5 Emerging Research Themes and Questions – Delivery Media

The use of emerging delivery media offers strong promise of promoting learning and retention. These technologies range from very simple (e.g., single-task activities such as typing tutors) to complex forms of simulation (e.g., collaborative simulations).

Classroom aids can be simple paper and pen tools that help to engage trainees and explicitly construct mental models. Attention to the physical and physiological aspects of the learning environment was seen in the literature review to have impact on learning.

Distance learning can involve different approaches to the use of technology. Geographically distributed synchronous, or asynchronous courses have been found to result in accelerated learning in both education and industry; though this may be most relevant in certain types of learning, and for certain types of individuals with high motivation and discipline for learning. The advantages of saving time (e.g., no travel required, less teaching time required with canned instruction) and financial resources (e.g., cost of travel, cost of instructors) which could reduce costs of training programs may be of particular interest to the CF.

Computer-based instruction was prominent in the literature reviewed. Although there was some evidence that computer-assisted instruction had positive impacts on learning, variance in the range of complexity of computer-based instruction makes it difficult to draw any strong conclusions about its general effectiveness. However, it is clear that using intelligent tutoring systems has very strong appeal for military systems, because they offer a range of time and cost saving potential. Given the potential importance of computer-assisted instruction, it will be necessary for future research and development efforts to target strong empirical knowledge about what kinds of computer-based instruction are the most effective for a given range of tasks, and how these systems can promote more efficient and effective learning.

Although varied in range and scope, there is also strong agreement in the literature that the use of simulation can promote better learning. At the simplest possible level, for a system that uses some forms of simulation to train its personnel, the key issue is whether simulation training actually does what it is intended to do. For example, does a simulator intended to train skills with small arms actually promote the intended learning outcomes (e.g., shooting effectiveness)? Even if simulation can be shown to be effective, though, it would also be ideal to show that the effectiveness of training is significantly different from conventional classroom/demonstration training. The impact of simulation-based training could also be explored from the perspective of the level of transfer that can be shown from simulation-based performance to real-world

performance on a live firing range. In this sense, it is clear that performance in a simulator may be the result of actual learning, but that if this learning cannot be "carried over" to real-world environments; it may be of limited value.

Understanding what aspects of simulation are most critical to promoting accelerated learning seems an important research issue.

The literature review showed a number of possible research questions, as shown in Table 6.

*Table 6 Findings and Research Questions- Delivery media*

| **Research Finding** | |
|---|---|
| **Delivery Media - Classroom Aids and Environment** | |
| Receptive, behavioural, guided discovery, exploration<br>Problem-solving focused training increases learning transfer (Schaab & Dressel, 2001)<br>Lecture-based instruction is found to be less favourable by many students (Schaab & Dressel, 2001) and ineffective in terms of accelerating learning (Meier, 2000) | What training approaches can help to accelerate learning? |
| Promoting visualization/development of mental models promotes learning<br>Novices tend to have mental models reflective of surface features while experts have more abstract mental models that prove more effective in performance (Schumacher & Czerwinski, 1992; cited in Andrews & Fitzgerald, 2010).<br>Visual learning techniques tend to be more effective than verbal learning techniques regardless of the preferred learning style (Pashler et al., 2008). | How can the emergence of mental models be supported by training techniques?<br>Do rich mental models promote accelerated learning?<br>Are mental models equally relevant to improving training effectiveness in varying skill domains? |
| Specific classroom-aids<br>"Hip pocket" training – impromptu training, short 15-20 minute lessons between the "cracks" (e.g., compass training during a water break while on a hike).<br>Concept maps (mind-mapping), flow diagrams, music, "serious" games | What aids are most conducive to learning?<br>Do these largely untested training aids (e.g., hip pocket, concept maps) promote accelerated learning? |
| Positive learning culture can foster effective learning (see Blume et al., 2010; Meier, 2000)<br>Learning transfer is significantly impacted by the transfer climate (Blume et al., 2010).<br>All 5 senses should be stimulated in order to achieve holistic learning (Meier, 2000; TLC, 2010). Overstimulation or unpleasant stimulation should be avoided (Erickson, 1991). | What aspects of the training environment most influence learning effectiveness? |
| Games provide novel and/or motivating methods of learning (Erickson, 1991; Cannon-Bowers & Bowers, 2008). | What technology has been used to provide effective gaming-based training that has led to accelerated learning?<br>What gaming-based technologies could be implemented to accelerate learning within the |

| Research Finding | |
|---|---|
| | CF? |
| **Delivery Media - Distance Learning** | |
| Optimal distance learning may depend on type of skill/knowledge, resources, and additional responsibilities of the instructor and student. | What skills are most conductive to the use of distance education?<br>Do skills taught via distance education show similar rates of decay? |
| **Delivery Media – Simulation-Based Instruction** | |
| Students who are exposed to and participate in immersive training learn faster and more effectively (see Meier, 2000).<br>Simulations can be used to create realistic, near transfer type training programs which is one method used to accelerate learning (see Cannon-Bowers & Bowers, 2008; Zipperer et al., 2003)<br>Simulations enable time compression required for accelerated learning (Hoffman, Feltovich, Fiore, Klein, & Ziebell, 2009) | How much fidelity is enough?<br>What aspects of fidelity are most critical to enabling accelerated learning (e.g., contextual embeddedness, tailoring to the individual)?<br>What trade-offs can be made between simulation-based instruction and actual practical tasks (e.g., flight time, range time, sea time)?<br>Does simulation-based training accelerate learning?<br>How can simulation-based training be used to tailor training to the needs of the individual?<br>Do all types of learners benefit equally from simulation-based training?<br>Does simulation-based training facilitate better transfer than conventional training to real-world contexts? |
| Technology can be implemented to facilitate training of geographically distributed students and instructors (see Cannon-Bowers & Bowers, 2008; Capuzzi Simon, 2007) | In team environments, can simulated-based instruction models substitute for team members?<br>How can simulation-based training be used to tailor training to groups and teams?<br>Can simulation-based training accelerate learning at the team level? |
| **Delivery Media - Computer-Based Instruction** | |
| Computer-based instruction (ranging from very simple to very complex tutoring systems) can promote higher levels of learning. For example, web-presented information significantly increased test scores compared with scores for control group (lecture style) (Cannon-Bowers & Bowers, 2008). | Can computer-based training accelerate learning?<br>Can computer-based training facilitate better levels of transfer to work performance?<br>What forms of computer-based instruction are most likely to help accelerate learning?<br>How does computer-based training relate to transfer to real-world contexts?<br>Do intelligent tutoring systems work better if they are tailored to the needs of the individual?<br>Are there means to accelerate learning through capitalizing on informal learning (vs. formal) using computer-based and technology-based information? |

## 2.6 Delivery Methods

A range of delivery methods are noted within the literature. A particularly relevant delivery method noted in the literature is collaborative learning. Delivery methods related to logistic aspects of planning and implementation of training programs such as scheduling, feedback and testing, adaptive instruction, and additional context and content factors also emerged.

### 2.6.1 Collaborative Learning

Whether students learn individually or in a group context may also influence learning (and by extension, accelerated learning). A common assumption is that collaborative learning can promote better learning. Collaborative learning can be defined as approaches that require joint intellectual efforts by two or more students. Some definitions also note the importance of the instructor within these collaborative efforts. An important distinction in the literature is between team training and collaborative training (Salas & Cannon-Bowers, 2001). Salas and Cannon-Bowers argue that team training is relevant to a team task, whereas collaborative learning involves group training, but not necessarily to perform a task as a team. This report uses the term "group" to cover both of these areas. Whatever the unit of analysis, Meier (2000, p.viii) succinctly argues that "collaboration among learners enhances learning". This section explores the empirical evidence in support of this assertion.

There is very good agreement about the power of collaborative learning. Group training can promote better learning because peer feedback can support learning performance, as well as vicarious learning (Salas & Cannon-Bowers, 2001). A review by Salas and Cannon-Bowers (2001) cites research by Shebiliske, Regian, Arthur and Jordan (1992) showing that collaborative protocols can cut instructor time and resources by 50%, as well as reducing the need for "hands-on" practice because of observational learning that occurred. Other research by Zipperer et al. (2003) within the military domain showed that levels of trust within teams contributed to higher levels of skill attainment, as well as increased retention of these skills. Similarly, teams with shared mental models have also been consistently shown to perform better. Encouraging shared mental models through high levels of communication or even cross-training can help soldiers understand how their peers, leaders, and joint services think, what they might need, and when they need it so information and assistance can be pushed at the proper time before the person who needs it has to request it (Zipperer et al., 2003). This would involve team members having clear knowledge about team procedures, the capabilities of other team members, interdependencies among sub-tasks, and which knowledge needs to be shared.

Obviously, the prevalence of a range of social networking tools also attests to the potential power of collaborative learning. Sites such as Facebook, Twitter, and LinkedIn are examples of ways to support and promote collaborative learning as well as connectedness in general. Whatever the form, then, collaborative learning can facilitate learning processes and promote training effectiveness

### 2.6.2 Scheduling

The scheduling of practice and training is a critical influence on learning and skill acquisition. For training, for example, the duration (length of a lesson or length of training program),

frequency (spacing of lessons), and the rate (speed of moving through content) of training are all important factors noted in the literature. Although there is recognition of the importance of these factors, optimal course duration and frequency of lessons or retraining is highly dependent on the type and complexity of the task (e.g., Kornell & Bjork, 2008 and Roher & Taylor, 2006; both cited in Andrews & Fitzgerald, 2010) and the length of time material that must be retained (e.g., Roher & Pashler, 2007; cited in Andrews & Fitzgerald, 2010; see also Ginzburg & Dar-El, 2000; Goodwin, 2006).

The importance of practice when working to acquire a new skill is well established. However, a review by Salas and Cannon-Bowers (2001) laments that precise conceptualization of practice and exactly how it relates to training outcomes has been overlooked or misunderstood. They argue that practice needs to be conceptualized as something more than simple repetition. Practice or retraining is argued to be of particular importance when tasks are infrequent (Cannon-Bowers & Bowers, 2008). Research has identified a rule of thumb to be used in assessing optimal spacing of practice. For example, Rohrer & Pashler (2007; cited in Andrews & Fitzgerald, 2010) proposed that optimal intervals between practice (and refresher training) are 10-20% of the retention interval (duration between the time a skill is learned or practiced and tested or performed) (Lance, Parisi, Bennett, Teachout, Harville, & Welles, 1998).

There appears to be little agreement in the literature about the impact of massed vs. spaced practice. In their review, Andrews and Fitzgerald (2010) identified research that demonstrated that spaced practice was more effective than massed practice in learning complex, cognitive skills However, little research was found related to procedural skills. Citing earlier research, a review by Rowatt and Shlechter (1993) reported that there was little difference in retention as the result of massed vs. spaced practice. However, research by Wells and Hagman (1983; cited in Rowatt and Shlechter. 1993) argued that spaced practice was optimal in 3 specific conditions:

- Dangerous tasks where fatigue would present risks to safety
- When students are not well motivated
- For high ability students, who might over respond to massed practice and become fatigued.

Even after training ends, a schedule that promotes active participation and hard work should continue in order to maintain skills and to further reinforce and develop learning. Andrews and Fitzgerald (2010) identified skill “stretching” as an important way to promote learning. This involves tailoring to the individual and presenting them with progressively more difficult challenges, such as the provision of tough or rare cases. This will help them to identify patterns of responses and respond to them. Thinking through these cases can provide opportunities to implement a newly learned skill. New challenges incorporated in training can keep students “on their toes” and maintain their interest which is a founding component of accelerated learning.

Zipperer et al. (2003) explored procedural skills and these researchers argue that mass training of procedural skills (e.g., hours of repetition) can be beneficial, and in some cases may be required prior to expanding or building on that skill. They also emphasize the importance of mastering the basics before adding challenges to training, as performance can suffer if the student is not proficient with the basic elements of the skills before additional levels of complexity are added (Zipperer et al., 2003). A recommendation noted in the literature is to allocate additional time to

initial learning (particularly with respect to procedural skills) and have subsequent practice or retraining sessions shorter.

The scheduling of training is also a critical influence on learning. The available literature addressed issues related to time compressed training (e.g., Andrews & Fitzgerald, 2010), as well as just-in-time training, as noted by Salas and Cannon-Bowers (2001). This form of training is scheduled to occur just before it is required. The shortened interval between skill acquisition and skill usage is argued to be a benefit of this form of training. Unfortunately, little description and information was available in the literature reviewed. However, scheduling of practice and training is an important theme noted in the literature.

### 2.6.3 Feedback and Testing

Feedback is critical to learning and to accelerated learning. Testing is one way that students receive feedback about their skill levels relative to the learning goal. Researchers advocate that "learners' memory for information or procedures can be directly enhanced through testing" (Roedinger and Karpicke; cited in Pashler et al., 2008, p.117). For example, a study by McDaniel, Roediger, and McDermott (2007; cited in Andrews & Fitzgerald, 2010) showed performance advantages after using a study-test model compared with a study-study model. Testing soon after material is learned seemed to enhance learning and maximize retention, especially when accompanied by corrective feedback. Retention research also shows that students who were tested (and provided feedback on their degree of success) during training performed better at retention than those who received only presentation training (Bryant & Angel, 2000; Goodwin, 2006). Testing may simulate the actual performance environment and/or stimulate the development of more effective strategies by students.

Training feedback can be provided by any number of sources. Trainers or instructors are typically the primary source of feedback. This section focuses on the type and timing of feedback and feedback provided from peers and instructors. Effective feedback must provide insight into correcting errors and information relevant to improving the organization of knowledge pertaining to the skill or task. A distinction can be made between effective feedback that provides direction on how to improve performance and feedback designed for encouragement (e.g., motivational feedback). The former can assist in increasing individual capability while the latter may improve personal commitment. Both may be important for improving performance; however, feedback specifically discussed within accelerated learning literature focuses on improving performance capability. Nonetheless, the importance of continued motivation of the student is evident throughout the literature relevant to learning.

Other students can provide critical forms of feedback that promote learning through shared problem solving, pointing out different perspectives, and providing corrective criticism. Using peer feedback (also called peer tutoring) during learning and practice is noted as being helpful to learning in the available literature and has been shown to aid learning. Importantly, research by Schaab & Dressel (2001) suggests that peer feedback has been demonstrated as a preferred method of learning for the majority of soldiers. Peer discussion and collaboration during learning and practice has been shown to provide students with necessary information to progress through a task and create knowledge. A study at Stanford University demonstrated that peer feedback was more effective than several other factors (i.e., reduced class size, lengthened instruction time, or individual computer-based instruction) at improving math and reading skills (Levine, Glass, &

Meister, 1987; cited in Meier, 2000). Peer feedback can be encouraged during learning by pairing savvy students with less experienced, novice students (Leibrecht, Wampler, Goodwin & Dyer, in preparation; cited in Schaab & Dressel, 2001). Pairs or groups of students can collaborate, providing feedback to one another as an effective form of learning because it fosters information exchange within a social context and allows students to share multiple perspectives (Cannon-Bowers & Bowers, 2008). As such, other students can be an important source of feedback.

The timing of feedback is also a critical factor. The majority of studies suggest that corrective feedback during learning or immediately after performance may be more beneficial than delayed feedback. Immediate feedback or help during problem solving has been found to be beneficial (Lajoie, 2003 cited in Andrews & Fitzgerald, 2010). Semb, Ellis, and Araujo (1992) provide empirical evidence that feedback while learning (in the form of tutoring) develops knowledge and leads to improved learning and retention.

In general, meaningful and timely feedback has been identified by a number of researchers as contributing significantly to learning (Meier, 2000; Andrews & Fitzgerald, 2010). What this looks like in practical application may vary significantly based on the type of skill or knowledge being learned, students' preferred style of learning, and resources (e.g., time, instructors, methodologies). Whatever the form, feedback is a critical part of learning as it provides advice for improvements to performance capabilities.

The type of feedback provided during training sessions can impact later retention. When feedback contains information about the magnitude and direction of performance errors the learner is directed toward correction, which can lead to better retention. This type of feedback is distinct from motivational feedback which though useful, does not provide any direct performance suggestions. Careful attention must be paid, however, to the frequency of feedback as students can become dependent on it. Feedback should be informative, but not become frequent enough to be a part of the students' mental representation of the task (Bryant & Angel, 2000). A study by Rowatt and Shlechter (1993) showed that corrective performance feedback can improve soldier armour skill retention as long as soldiers do not becoming reliant on the feedback.

Similar to findings related to feedback described within the accelerated learning literature, feedback in the retention literature can take the form of tests when accompanied with corrective criticism. Retention research concurs that students who were tested (and provided feedback on their degree of success) during training performed better at retention than those who received only presentation training (Bryant & Angel, 2000; Goodwin, 2006). Testing may simulate the actual performance environment and/or stimulate the development of more effective strategies by students.

Feedback should be incorporated into training programs in order to achieve a high level of retention. Both the amount of feedback and feedback frequency require optimization. Further investigation of what factors affect feedback effectiveness is required for the specific training in question.

A critical issue is the relationship between accelerated learning and retention. Even if learning can successfully be accelerated, a critical question is how well the knowledge and skills learned will be maintained over time. Critics suggest that retention of "speedy" learning would suffer compared to retention in traditional learning (see Capuzzi Simon, 2007). However, research by

Bailey (1989; cited in Ginzburg & Dar-El, 2000) suggests that the rate of learning is not related to learning decay (or forgetting) which is a function of the amount learned and the break duration.

### 2.6.4 Adaptive Instruction

In traditional training, the learning rate is controlled by the instructor. Typical classroom learning consists of an instructor giving a presentation or lecture and material is covered as quickly or as slowly as the instructor decides.

The available literature is clear on the importance of adaptive instruction. This can be defined simply as tailoring to ensure some match between how the learning process is designed and structured and the needs of the student. There is some evidence in the literature that learning can be increased by providing students with control over tasks performed or by providing the student with control over the pace of learning (Cannon-Bowers & Bowers, 2008).

The introduction of technology presents new options for customizing training to accommodate various rates of learning. For example, blended online and in-class courses are becoming prominent in post-secondary institutions. Students often choose the type of course they would like to take, which gives them greater power in controlling how the information is presented (e.g., on-line courses are often over the Internet using many visual resources) and the pace at which they learn (e.g., in online courses, the pace of learning is often controlled by the learner) (Capuzzi Simon, 2007). Providing this choice may lead to greater learning if students feel they have control and responsibility for their own learning, as well as choosing a learning pace that best suits their unique learning style and abilities. Indeed, research has shown that students in accelerated programs can achieve final grades similar or better than those of college students learning the same material (Capuzzi Simon, 2007).

Adaptive instruction is relevant both to the original design of the course, as well as to the process that unfolds as the student is taught. Intelligent tutoring systems, for example, can be designed to be responsive to errors that the student makes and to identify problematic themes that the student does not seem to understand. Targeted remediation, then, is a critical part of adaptive instruction.

Overall, then, there is good agreement that adapting instruction to match the needs of students will help promote better learning outcomes.

### 2.6.5 Context and Content

Our review of the literature showed a range of other relevant topics that are specific to the context or content of training, but which do not easily fall into discrete categories. These topics are explored within this section.

#### 2.6.5.1 Training Context

The importance of context in learning is a persistent theme noted during the literature review. As Meier (2000, p. xviii) argues “the best learning comes from doing the work itself in a continual process of “real-world” immersion, feedback, reflection, evaluation and re-immersion”. This is true at the level of the individual student, as well as in thinking about the meaning of training

within an organizational system. Training is no longer seen as an isolated event that occurs outside of the application context, but "…organizations have shifted their views about training from a separate, stand-alone event to a fully integrated, strategic component of the organization" (Salas & Cannon-Bowers, 2001, p. 472). Baldwin et al. (2009) also noted that there is a need to more explicitly address the social environment and organizational context of training activities and also a need to categorize, investigate, and report contextual variables that may influence transfer (Baldwin et al., 2009).

Research is clear about the importance of contextual learning, and suggests that "we gain the most by actually doing the activity that we are being trained to do" (TLC, 2010, p.2). Training should closely reflect the actual "in-the-field" or "on-the-job" tasks (Andrews & Fitzgerald, 2010; Meier, 2000; TLC, 2010). Achieving good results in performing real-life tasks can develop competence and confidence essential for good performance. Zipperer et al. (2003) recommend realistic hands-on experience for soldier training. According to the authors, students should be immersed in realistic, challenging tactical environments and exercises should include live fire, live explosives, heavy loads, medical treatment, evacuation drills, and fast-paced combat operations.

Cannon-Bowers and Bowers (2008) further argue that experiential learning is vital to effective learning. Anchored instruction, defined as instruction that is based in a meaningful context, provides students with experiences of how a concept may be applied which leads to new learning and promotes the development of mental models and integration of learned information.

Another assertion in the literature is that learning is more effective when learners and students are provided with deeper information about the underlying problem. This may depend on whether the goals of learning are related to "why" or "how" and "what". In some cases, the goal of training/education may be to elucidate the deeper principles associated with an issue. In other cases, the goal is simply to teach students how to perform a specific and isolated skill. Some researchers have argued that "training must provide increasingly detailed knowledge procedures and principles, in context, with progressive refinement as expertise develops" (Wulfeck, 2008; as cited in Andrews & Fitzgerald, 2010, p.6). The assertion that students will learn better if taught the foundational principles of a problem rather than the specifics with no principles or background is a consistent pattern in the existing literature (e.g., Meier, 2000).

#### 2.6.5.2 Training Content

Various aspects of training content are noted in the literature. These include cross-training, overlearning and active versus passive learning.

**Cross-training** is one prominent form of training noted in the available literature. Cross-training is designed to help build shared team mental models. Cross training requires team members to understand the entire team function, and the role that one's particular tasks plays within and between those of other team members. One way of doing this is by having team members swap roles temporarily. Volpe et al (1996; as cited in Adams, Webb, Angel, & Bryant, 2003) found that cross training amongst two-person air combat crews led to better individual performance, more effective team communication, and improved teamwork. Further, naval three-person teams that received cross training were found to have no decrement in speed or accuracy in the case of

unexpected role substitution (McCann et al., 2000; as cited in Adams et al., 2003); teams that did not receive cross training did see a significant decrease in performance.

**Over-learning** is another technique noted in the accelerated learning literature. Overlearning is defined as training and practice "beyond the attainment of criterion-level performance" (Lance et al., 1998. p. 105; see also Andrews & Fitzgerald, 2010; Zipperer et al., 2003). That is, practicing a task not only to the point of proficiency, but over and beyond that point until the task seems to come automatically and students could perform it "with their eyes closed". Over-learning is essentially considerable repetition of a task during training and is often used in the acquisition of physical and procedural skills. A goal of over-learning a procedural task is to instil muscle memory, making a task automatic (Zipperer et al., 2003). Simple repetition, however, is not enough to effectively master a skill. Thought and reflection should supplement and precede repetitive drills (Zipperer et al., 2003), and thus must be considered in respects to planning and time allocation for training. A combination of repetition and visualization may be as effective as an overlearning approach. However, it is also important to note recent work that casts some doubt on the effectiveness of overlearning (e.g., Andrews & Fitzgerald, 2010). Nonetheless, overlearning is a commonly cited training technique cited in both the learning and retention literature.

**Active vs. passive learning** - Another factor argued to impact on learning and on accelerated learning is whether the learning is active or passive. Active learning can be defined as engaging the student and requiring them to apply effort in order to acquire and practice a skill or knowledge. Active learning is often associated with high amounts of motivation, and more learner involvement (e.g., researching information themselves). Passive learning requires less active involvement on the part of the study, and they are assumed to absorb the information that is being presented to them such as in lecture-style learning. Active learning is argued to promote better learning. Meier (2000), for example, argued that learning requires active participation and hard work. The argument that learning is facilitated by active motivation and participation of the learner is also evident in the term "total learner involvement" (Meier, 2000), and seems to be related to the term "experiential learning" (Cannon-Bowers & Bowers, 2008).

There is good evidence showing the benefits of active rather than passive learning. For example, research by Healy, Ericsson, and Bourne (1990) showed simply reading an association (whether multiplication or word based) was not as effective a learning process as having subjects generate or recollect (e.g., calculate) the proper responses during initial training. This "generation effect", involving the subjects as active players in generating responses, resulted in a much higher retention rate when assessed weeks and months later. This effect was demonstrated through simple numerical associations. Tasks requiring participants to perform the mental calculation themselves (verifying numbers and generating answers) showed higher retention rates than when the learner was more of a passive observer (e.g., reading answers). Thus, the researchers provide evidence that when the student is actively engaged through mental calculation, retention is increased. Active participation is key to improving learning and retention.

There is some evidence in the available literature that more active learning can promote better learning outcomes. Research by Schaab and Dressel, 2001; cited in Goodwin, 2006) involved military intelligence officers trained using either traditional techniques (guided demonstration) or more active constructivist techniques (e.g., working in groups on practical exercises – guided exploration). Results showed that although both groups did well on the final exam, the guided

exploration group showed better performance on novel practical exercises and reported lower levels of cognitive load. This suggests that active learning techniques may promote better learning.

**New Age Techniques -** A review by Swets and Bjork (1990) evaluated a range of "new age" techniques for training conducted by the Army Research Institute (ARI). The National Research Council (NRC) was commissioned to assess extraordinary techniques developed outside typical mainstream research in behavioural sciences. A committee was formed through the NRC called the Commission on Techniques for the Enhancement of Human Performance and took responsibility for conducting the research. They audited unique training techniques that were accompanied by strong claims of effectiveness.

Topics specifically of interest to the ARI included learning efficiency, improving motor skills, altering mental states, stress reduction, group cohesion and interpersonal group processes (e.g., the impact of group cohesion on individual and group performance) and parapsychological processes (e.g., mental influence on remote machines). The ARI was interested in realizing possibilities of learning while sleeping, or accelerating learning based on packaged programs that include guided imagery, mental practice, visual concentration, and biofeedback. Further, additional concepts were explored that could serve to optimize performance by altering a student's mental state by means of self-induced hypnotism, meditation, focused concentration and integration of activity in the brain's hemispheres.

The NRC committee found no evidence of positive learning during sleep, for the usefulness of a specific accelerated learning program (SALT), and no support for parapsychological approaches to training. They concluded that mental practice or rehearsal and learning was well supported, but that increasing visual skills through training was not, and evidence was lacking for the use of biofeedback to improve motor skills. Stress was argued to impact on training effectiveness, and the committee found that neurolinguistic programming (NLP) had promise, but had not been shown to be effective. They also concluded that the impact of group cohesion on learning was poorly understood.

**Visualization and mental rehearsal -** Other reviews focused on the importance of being able to visualize a problem as an important part of learning. Visualization is argued to promote learning because it promotes a student's active role in mentally "organizing" information required to perform a skill or task. Some researchers suggest that visual learning techniques tend to be more effective than verbal learning techniques regardless of a student's preferred learning style (Pashler et al., 2008). The emergence of a mental model is often described as the logical culmination of visualization processes and the accumulation of an integrated knowledge structure. Encouraging students to form mental models is another strategy commonly used to promote higher levels of learning. Novices become increasingly good in a task by developing more organized and abstract mental models. Guided imagery can also lead students through mentally performing a skill or task that can speed up learning and improve performance. Mental images created by the student and have been shown to increase recall (TLC, 2010).

Visualization has been frequently used as an important technique in mastering skills within military contexts (Zipperer et al., 2003). Military training subject matter experts (SMEs) agreed that cultivating realistic scenario-based imagery of a task is an essential first step to skill mastery, particularly in procedural tasks conducted by dismounted combat troops. To aid this technique,

live, video, auditory, and model-based or simulation-based demonstrations could provide necessary information on which visualization can be based (see Erickson, 1991; Fu et al., 2009; Zipperer, et al., 2003).

A technique called symbolic mental rehearsal (SMR) has also been shown to improve learning of computer skills. Research conducted by Davis and Yi (2004; cited in Goodwin, 2006) required participants to use this mental imaging technique to parse the steps of a task into a spreadsheet, assign labels to them, and to mentally rehearse the order of these labels. Results showed that SMR improved learning, even with a number of other variables (related to instructors, age, computer experience) controlled.

A specific learning technique relevant to the emergence of mental models is problem-based learning. Collard et al. (2009) conducted a study using problem based learning (PBL) techniques that focused on building expertise by developing knowledge structures. PBL was developed to assist students in developing knowledge constructs into organized, effective mental models. The purpose of PBL is to improve cognitive processes, particularly problem solving skills, and build stronger knowledge networks that ease acquisition and integration of new information and retrieval of stored information.

Collard et al., (2009) investigated the factual knowledge and the strategic skills (i.e., reasoning) of medical students enrolled in a PBL-based curriculum. The study showed that year 3 students performed better on factual knowledge measures compared with upper year students (year 4-6). Year 3 students, as expected, performed worse than upper year (5-6) students on the reasoning test. For the lower-year students, factual knowledge and reasoning was correlated. This may indicate that their mental models (or knowledge networks) used in reasoning tasks are closely related to factual knowledge. Upper year students did not show this correlation which suggests that these students, having more experience and knowledge of the field, may have developed more complex and abstract mental models that are more effective for problem solving and reasoning tasks. The main educational difference between these two groups was hours of hands-on experience. Year 3 students had none, upper year students had from 4-16 months (halftime, or a mixture of halftime and fulltime). Though it was not the focus of this study, this finding provided evidence that may support practical hands-on application of knowledge as means of developing abstract, expert mental models.

As a whole, then, our review of the literature suggests that there are a range of contextual and content-related issues likely to impact on learning.

### 2.6.6 Emerging Research Themes and Questions – Delivery Methods

This chapter shows that many different delivery methods are likely to impact on learning and training effectiveness. These include collaborative learning, scheduling, feedback and testing, adaptive instruction and issues related to context and content within which training occurs.

Many military tasks require collaboration and teamwork. Evidence shows that learning with others (e.g., sharing of information, developing shared mental models) can promote positive learning outcomes. Increased use of social networking tools may also promote new types of collaboration that are not yet well understood, nor researched.

Scheduling focuses on issues of timing, duration, and spacing of initial learning and subsequent practice that determines the frequency and intensity of which trainees are expected to learn. Scheduling lays out when and how learning and testing should occur. Although there is some evidence in the literature about the impacts of varying training schedules (e.g., just-in-time, time compressed), there was little agreement about the best way to promote a high level of proficiency in a reduced amount of time.

Feedback is noted in the literature as an important influence on learning. The level of detail, frequency (e.g., continuous intermittent), and process (e.g., timing vs. delayed, source of feedback) of providing feedback can all influence learning. Understanding these components as they relate to promoting positive learning outcomes requires more research, and it may be beneficial to look at the specific training in question. Although there is some discussion of the role of both instructors and peers in feedback, there is little sense in the available literature that the potential power of feedback from peers has been grasped. As training often occurs within a collaborative environment, the issue of feedback (and particularly the nature of collaborative feedback) may be worth exploring in more detail.

There is some agreement in the literature about the importance of tailoring training approaches to the needs of students. Adaptive instruction may be one method of increasing their motivation or providing students with a sense of control over their learning which (for these reasons or others) leads to accelerated learning.

Issues of context and content are also critical issues to thinking about delivery methods. These relate to the efficacy of principle-based learning that focuses on "why" learning needs to occur, as opposed to the simple provision of information. The potential impacts of overlearning and different forms of training (e.g., cross-training) also need to be better understood within the unique military environment.

There is a rich set of potential issues related to delivery methods that would be possible to explore in future R & D efforts. Relevant research findings as well as potential research and development opportunities are shown in Table 7.

*Table 7 Findings and Research Questions- Delivery methods*

| | |
|---|---|
| **Delivery Methods – Collaborative Learning** | |
| Collaborative tools can promote better learning | Do collaborative tools promote learning?<br>What collaborative technologies show the most promise of promoting accelerated learning?<br>What collaborative technologies might be used in training to promote accelerated learning (e.g. Facebook, Twitter, SMS)?<br>How do distributed teams learn most effectively? |
| Collaborative training can promote learning. Collaboration among students can provide different perspectives and enrich the learning experience (see Schaab & Dressel, 2001). | What types of skills are most conducive to collaborative benefits during training? |

| | |
|---|---|
| **Delivery Methods-Scheduling** | |
| Practice - Need to constantly "stretch" skills to have accelerated learning – need to have increasing levels of difficulty<br>Spaced practice was more effective than massed practice in learning complex, cognitive skills (Andrews & Fitzgerald, 2010). Procedural skills can benefit from mass training (e.g., hours of repetition) (Zipperer et al., 2003) | How should practice be scheduled (spaced or massed) for varying types of skills?<br>What is the relative effectiveness of different training schedules?<br>What kinds of "stretching" of skills are optimal (e.g., complexity, rates, duration, unique challenges). What are the ideal rates of "stretching"?<br>What training technologies are most helpful in providing practice that "stretches" skills sets, can be tailored to the performance of the individual? |
| Training design - Evidence supports front loading mass-instruction (high frequency) for procedural skills (see Zipperer et al., 2003) | How should training be designed to accelerate learning within specific skill areas? |
| **Delivery Methods – Feedback and Testing** | |
| Feedback - Immediate feedback during training /performance is most effective (Lajoie, 2003 cited in Andrews & Fitzgerald, 2010; Semb, Ellis, & Aarujo, 1992)<br>Feedback can be provided by the instructor or peers (i.e., tutoring) (see Schaab & Dressel, 2001; Zipperer et al., 2003) | What are the optimal rates of feedback?<br>What are the optimal rates of testing?<br>Does feedback help to accelerate learning, and if so, how?<br>Does real-time feedback to trainers of student understanding (e.g. use of clickers in the classroom) help to accelerate learning?<br>Do instructor and system feedback have the same effects? |
| **Delivery Methods – Adaptive Instruction** | |
| Learning should be tailored to individuals<br>Personalized training is more interesting, easier, increases motivation and consequently increases learning (see Andrew & Fitzgerald, 2010; Meier, 2000)<br>Low-ability students benefit from highly-structured learning environments and high-ability students benefit from low-structured learning environments (Pashler et al., 2008) | What types of adaptive instruction are most critical to promoting accelerated learning (e.g., rate of presentation, practice)?<br>Dynamic remediation - What training technologies provide the best flexibility for promoting tailoring of instruction (e.g. computer-based tutors)?<br>How can technology be designed to maximize responsiveness to the student? |
| Instructors - Matching supervisory styles with the capabilities and commitment of the student can result in more effective training (Hersey & Blanchard, 1977) | What instructor behaviours facilitate accelerated learning?<br>How does the level of instructor training and expertise influence learning? What aspects of their expertise are most critical to maximal learning? |
| **Delivery Methods – Context and Content** | |
| Contextual embeddedness improves learning | Can overlearning help to accelerate learning? |

| | |
|---|---|
| (Meier, 2000) | How much stress is pest?<br>Is cross-training a good method of promoting learning and retention?<br>What forms of contextual learning are most advantageous?<br>What technologies best support contextual embeddedness? |
| Using principles (why training is necessary) create foundational knowledge that improves learning (Meier, 2000) | Does presentation of background and principles promote accelerated learning?<br>What are the time/efficiency trade-offs for accelerated learning? |

## 2.7 Skill and Knowledge Retention

Previous sections addressed factors associated with accelerated learning and transfer. This chapter samples the literature concerning retention of skills and knowledge.

### 2.7.1 Introduction to Retention

Retention can be defined as the maintenance or sustainment of learned behaviours without practice (Schendel & Hagman, 1991; cited in Rowatt & Shlechter, 1993). Others have defined retention as "the degree of competence to which an acquired skill [or knowledge] is retained through the passage of time" (Ginzburg & Dar-El, 2000, p. 327). Another definition is that "Skill fading (or reduction of skill retention) is the measurable decrement in performance of a skill relative to a criterion" (Bryant and Angel, 2000, p. 14).

In general, it is clear that skills generally decay with the passage of time (Ginzburg & Dar-El, 2000). Further, skill loss research suggests that there is a proportionately large degree of skill fading after relatively moderate amounts of time, as shown in Figure 2.

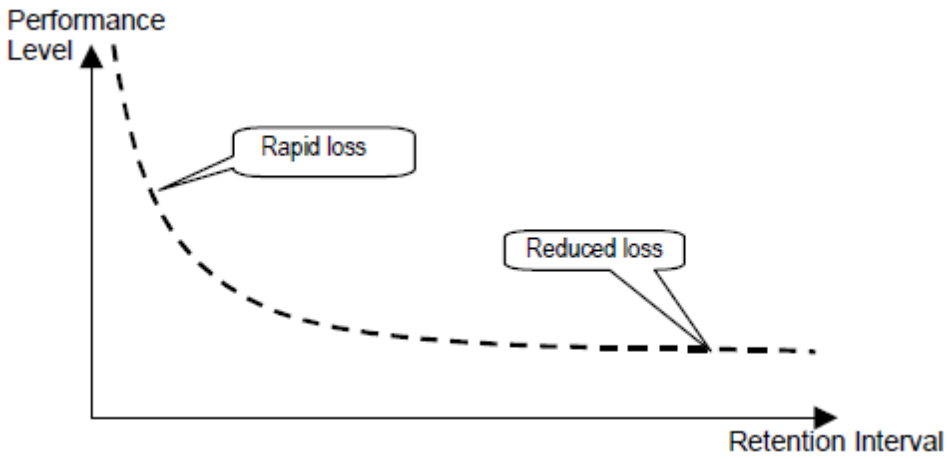


*Figure 2 Relationship between retention performance and retention interval (Adams et al., 2003)*

Retention is a function of the amount learned and the duration between task performances. This interval between learning or performance and a subsequent performance is called the *retention interval* or Skill Retention Interval (SRI) (e.g., Lance et al., 1998). This interval is graphically represented in Figure 3.

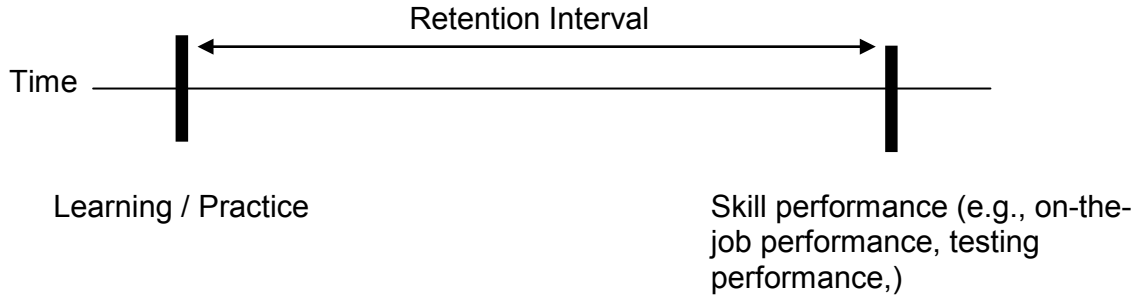


*Figure 3 Skill Retention interval (SRI)*

### 2.7.2 Retention- Relationship to learning factors

Given that there is obviously a relationship between the acquisition of knowledge and skills and their retention over time, a key issue is the exact nature of this relationship.

Our review of the literature offered some limited insight into factors that influence retention, and showed a number of factors that are likely to affect retention rates after learning. These factors include student and instructor attributes, the media through which training is delivered, the methods used to conduct training (e.g., schedule of practice).

Our review of the literature showed some overlap with some notable findings in the learning literature. For example, both literatures address some common student attributes, such as

cognitive ability and relevant background knowledge. Although cognitive ability has been shown to increase the rate at which information is acquired, it does not seem to affect the rate of decay. However, because individuals with higher ability may learn at a faster rate, they are typically able to achieve a higher overall level of learning within the same training duration (Goodwin, 2006). This heightened level of original learning, then, means that they can show better retention. As skills have been shown to fade at a somewhat consistent rate (independent of aptitude), people with higher cognitive abilities will retain more than people with moderate rates of initial learning.

Background knowledge is also cited in the literature as a potential influence on skill retention. This has been shown in a range of studies reported by Goodwin (2006). This finding is attributable to the fact that better background information on a given topic would facilitate the emergence of a more organized and coherent knowledge structure that might be easier to retain over time. However, this area is particularly underdeveloped from a research perspective and seems to lack strong designs and controlled experiments.

Other individual factors prominent in the learning literature, such as self-efficacy, motivation, and positive emotions are less prominent in the literature relevant to retention. However, expertise is argued to increase retention of newly formed skills (Andrews & Fitzgerald, 2010).

Although there are many forms of delivery media (e.g., classrooms, distance learning, simulator-based learning), direct comparisons of their impacts on retention were not found in the literature. There is evidence that existing literature is inadequately developed to begin to answer this question. For example, a review by Goodwin (2006, p. 8) exploring the literature relevant to digital skills argues that the retention levels associated with the efficacy of specific training approaches (e.g., guided vs. unguided) "is still a relative unknown". Moreover, the studies that do exist do not extend more than a month, and rely primarily on tests occurring soon after the end of training.

Delivery methods have clear connections with skill and knowledge retention in the literature. The schedule and nature of refresher training and its relationship with retention are notable examples of this connection. Retention of a skill can be maintained if retraining or practice is implemented at an optimal time. However, many factors influence this relationship and would affect the decision of timing and implementation. Ginzberg and Dar-El (2000) argue that although it is clear that skills fade over time, the right kind of retraining can return skilled performance to similar original levels, and this relearning time is quicker than the initial training though, with more passage of time between original learning and relearning periods, relearning will take more time. They also note a concept called the "warming up" phenomenon, namely that the most critical moments of retraining are the first few minutes. Active participation is another training technique that has been shown to increase learning and accelerate training, as well as promoting better levels of retention and performance (see Meier, 2010).

The retention literature supports the effectiveness of training programs that are spaced according to the nature of the task and individual students in order to minimize fatigue, increase motivation, and ensure a proficient level of learning is achieved. Optimal durations between training segments were not specified as they would be affected by the particular skills and students involved. Unfortunately, the logistics of training programs often dictate the duration and frequency of training, resulting in training and practice being massed together (e.g., longer hours of training with fewer sessions). This is particularly true in the military. For retention, this can

have negative effects. It is problematic "…that conditions that make performance improve rapidly during instruction or training such as blocking or temporal massing of practice can fail to support long-term retention and transfer." (Pashler et al., 2008, p. 117).

A higher level of original learning has been related to higher retention performance. As a review of the retention literature by Rowatt & Shlechter, 1993, p. 2) states "…nearly all of these reviews have indicated that this variable is the single best determinant of skill retention with the relationship between original learning and retention remaining highly positive and stable for an indefinite period of time".

The most common means of reducing the retention interval is through the provision of refresher training. The length of time required for refresher training (or relearning) has been consistently found to be shorter than the original training period. More specifically, studies have shown that the length of time required for refresher training is less than 50% of the time required for the initial training (Rowatt & Shlechter, 1993). However, long intervals between initial training and retraining mean that relearning will require more time.

There is evidence in the literature that more practice does not always mean higher retention. Shute and Gawlick (1995; cited in Bryant & Angel, 2000) compared a full practice session to an abbreviated practice condition (which was about 25% of the full) and found those in the abbreviated condition had better retention. They supposed that students in the abbreviated condition devoted greater effort during training to compensate for fewer practice trials. Other students received half abbreviated training and half full training. These students performed the best of all, suggesting that variable practice schedules enhance retention (Bryant & Angel, 2000). This finding was further supported by Goodwin (2006) who found that greater interference at time of learning (i.e., a random versus a blocked schedule) produced higher levels of retention and transfer.

A study by Lance et al. (1998) conducted a study with 8 samples of U.S. Air Force personnel (from different specialities) investigating the relationship between retention interval and task performance in terms of 3 potential moderators. These included initial skill learning, student aptitude, and the level of task difficulty. Initial skill learning was assessed based on the students' experience levels. Results showed that the longer the SRI, the poorer the task performance; however, the SRI did not account for most of the variance in test performance. Specifically, via a regression analysis, they concluded that only "…about 10% of the variance in task performance was accounted for by the length of SRI" (p. 118). This might have been because of restriction of range, as there were few long SRIs in the sample, and participants were more homogeneous (due to being selected) than was ideal. The lack of experimental control (e.g., participants might have been required to perform similar tasks in other parts of their jobs), and other moderators that were unmeasured might have lowered the strength of the relationship. Initial skill learning and student aptitude did not significantly moderate the retention interval/task performance relationship. Unfortunately, although this study asks important questions, the scientific quality of this research is problematic.

The type of task being performed is reported to influence optimal timing for retraining or practice. For example, spaced trials tend to result in less skill decay for verbal tasks (Goodwin, 2006). A review by Goodwin (2006) found little within the literature on the effects of different training schedules on retention of digital skills. Training for a particular skill requires

examination of the literature pertaining to that skill, and /or its own empirical research to investigate retention effects as there seems to be no effective "one size fits all" methodology for scheduling. However, there is some evidence in the literature that some conventional measures of aptitude show differential retention of different types of skills. For example, Goodwin (2006) cites previous research as showing that ability scores were more strongly associated with retention of performance on mental tasks than "hands-on" or psychomotor tasks. This suggests that cognitive abilities may interact with the type of skill in question to influence retention of these skills.

Ginzburg and Dar-El (2000) used a partial simulator to investigate the relationship between relearning and skill retention duration in military training relevant to Electronic Warfare. Participants from the Israel Defence Force, Electronic Warfare Unit were divided into four groups, each having a different retention interval (retention intervals were 1 month, 2 months, 3 months, and 6 months). The specific tasks and procedures using the partial simulator were not detailed; however the task was described as operating a complex electronic system.

Results showed that procedural skill decay occurred faster than decay of psychomotor skills (Ginzburg & Dar-El, 2000), and controlled skills decayed faster than automatic skills. Findings indicated that operators' level of performance conformed to the typical retention curve (performance declined as the retention interval increased). Refresher training fully restored skill levels in the one month and two month conditions. After three months, however, skills were not fully restored through this additional refresher training. At this point, more training was required to fully restore skill proficiency. The authors argue that for this specific training task, two months was the optimal length of time between retraining in order to restore operator performance to the acceptable level of proficiency.

The similarity between the training situation and the transfer situation are also noted in the literature as a critical influence on levels of retention (Rowatt and Shlechter, 1993). When the training task and the transfer task share common structural elements, students are likely to be show higher levels of transfer. Obviously, this means that tailoring the training environment to the nature of the skills to be achieved is critical. However, an interesting issue noted in the literature is that the impact of functional similarity is relative rather than absolute. Specifically, student perceptions about functional similarity seem to matter more rather than objective function similarity (Druckman and Bjork, 1991; cited in Rowatt and Shlechter (1993). This is also in line with high fidelity offering learning advantages. The retention environment needs to provide the perceptual and cognitive cues required to retrieve the learned skill from memory, otherwise performance will suffer (Bryant & Angel, 2000). A simple example involves typing in numerical data. Healy et al, (1990) looked at numerical data entry on the number row versus using a numerical keypad. They found that skill retention (measured as speed of data entry) was only maintained when using the same type of data entry. Thus, entering a sequence of numbers on the keypad only resulted in faster entry times if entered on the keypad during retention testing. If first entered on the number row, and then on the keypad then significantly less of a retention effect was found even if the same sequence of numbers was used. They concluded that "it is crucial to make sure that the procedures we use when learning the information are reinstated at the time we need to recall the information" (Healy et al., 1990, p. 97).

Both field and laboratory retention studies have been conducted to understand retention. Generally, laboratory studies have shown greater retention; however, critics point out that tasks

are often fabricated and may not reflect realistic work-related tasks (Lance et al., 1998). Research demonstrated that armour skill retention is a function of several instructional and task factors. Specifically related to near transfer, researchers found that soldier retention of armour skills can be maximized by making training requirements functionally similar to on-the-job performance requirements (Rowatt & Shlechter, 1993). Thus, retention, as measured through task performance, is expected to be better when training more closely reflects the evaluated task. This is further supported by research on "learn-by-doing" techniques which have been shown to improve learning of procedural skills (Healy, 1997; cited in Bryant & Angel, 2000). Applying this more generally to military settings, Hagman & Rose (1983; as cited in Rowatt & Shlechter, 1993) noted that field exercises are more appropriate for promoting task acquisition and retention for military field purposes. In general, near transfer can facilitate retention. Training programs, practice, and refresher training should focus on tasks that directly reflect on-the-job performance.

How knowledge is organized during training has also been shown to impact retention. The easier tasks are to organize mentally, the faster the tasks are learned (Adams et al., 2003). This applies to learning simple data, as well as to more complex procedural tasks, which if well organized, show longer retention levels. Essentially, simpler tasks should be more easily organized than more complex tasks. Additional time to learn and organize information related to complex tasks may be required in order to maintain and retain the skill. Effective organizational strategies can also be implemented by instructors. Some examples include reminding learners of their currently possessed knowledge and how that knowledge relates to the new knowledge, making repeated use of information presented from different perspectives, and encouraging students to elaborate on the material during learning (as well as during later application). When appropriately applied, each of these strategies has led to improved learner retention (Adams et al., 2003). In terms of feedback, retention research states that students who were tested (and provided feedback on their degree of success) during training performed better at retention than those who received only presentation training (Bryant & Angel, 2000; Goodwin, 2006).

As a whole, then, research suggests that optimal spacing for training and amount of training and practice should be developed based on the unique characteristics of the training program in question. Randomly spaced training and compressed training schedules (e.g., implementing abbreviated versions of training programs) can increase retention. However, motivation of the students and other such factors may also impact retention outcomes.

There is some consistency in the factors noted to influence skill acquisition and skill retention. As previously mentioned, the learning and training literature suggests that techniques such as over-learning can be used to train individuals above proficiency. Similarly, over-learning has also been shown to enhance retention (Bryant & Angel, 2000; Goodwin, 2006; Lance et al., 1998; Rowatt & Shlechter, 1993). Research by Driskell, Willis and Cooper (1992; cited in Salas & Cannon-Bowers, 2001) showed a significant relationship between overlearning and retention, but this relationship was moderated by the level of overlearning, length of retention interval and the type of task. It is believed that over-learning enhances the strength of associations between stimulus and response as well as encouraging automaticity (Schendel & Hagman, 1982; cited in Lance et al., 1998). Earlier research also showed that overlearning promotes student confidence and reduces stress (Martens, 1974: cited in Lance et al., 1998). Some limits to the benefits of over-learning have been found. Driskell, Willis and Cooper (1992; cited in Bryant & Angel, 2000) conducted a meta-analysis and suggested that a minimum of 50% over-learning was required to

gain any positive effects. This suggests that valuable training time can be wasted if too little over-learning is attempted.

As noted earlier, learning research also argues that the more involvement that subjects have in active participation during learning, the better their subsequent performance. This pattern also seems to apply to retention. This was demonstrated in an experiment conducted by Healy et al. (1990) which showed that when subjects were active players in generating responses they had a much higher retention rate weeks and months later.

However, the factors that influence skill acquisition are not necessarily the same ones that influence skill retention. For example, one specific factor that shows a distinct pattern relates to contextual interference. Although some researchers have argued that having a consistent, blocked schedule of training leads to faster acquisition of learning than with a random schedule, interference has the opposite effect on the retention of learned information. Battig (1979: cited in Goodwin, 2006, p. 17) proposed an "intra-task interference principle of memory" namely, that "greater interference at the time of learning produces higher levels of subsequent retention and transfer". Goodwin (2006) cites reports showing contextual interference effects associated with a 30-50% gain in recall performance.

For the future a critical requirement is to understand the relationship between the factors that promote learning and those that influence retention.

### 2.7.3 Models of Retention

For trainers and educators, the ideal would be to know when skills that have been acquired need to be refreshed. Unfortunately, there are no prescribed standards for the amount of training or practice required to sustain skill levels, but there are some models that are relevant.

For example, Bryant and Angel (2000) discussed a number of quantitative predictive models related to retention. The most promising of these in their view was the Army Research Institutes' (ARI) Users' Decision Aid (UDA). This model allows trained evaluators to answer ten simple task-related questions (e.g., the number of steps, execution demands, task time limits, etc.) and calculate the "retention score" for that task. The UDA model splits the complexity of a task into three categories: number of steps, whether the sequence of the steps matters, and whether or not there is inherent feedback that indicates correct task performance. Each of these sub-factors was found to have effects on skill retention. Once calculated, retention scores can then be looked up on a prediction table, to determine the frequency with which refresher training should be applied. This model has been empirically evaluated within a limited domain and found to be an effective tool for determining refresher training frequency.

Unfortunately, this model seems best suited to relatively simple procedural skills, and there is little evidence in the literature of other pragmatic models that would help to understand the retention of more complex skills.

### 2.7.4 Techniques for Retention

Our review of the literature showed a number of tools and aids that might help to accelerate learning. These tools, of course, are designed to instantiate some of the core principles of learning described earlier in this report. For example, concept maps (or mind maps) are intended to promote the use of visualization. Unfortunately, the scientific validity of these tools remains unclear, and whether they are likely to help accelerate learning remains unknown. Having validated tools and aids shown to facilitate learning and retention could be an important contribution.

Mnemonics are also noted in the literature as likely to help promote retention of skills. They are defined as "strategies employed to impose meaning and/or organization on complex materials or skill to facilitate learning or retention (Wells & Hagman, 1991; cited in Rowatt and Shlechter, 1993, p. 8). Research suggests that allowing learners to develop their own mnemonics enhances retention and transfer of procedural tasks (Druckman & Bjork, 1991; Wells & Hagman, 1991; cited in Rowatt & Shlechter, 1993). Other memory aids are also noted in the literature (e.g., Erickson, 1991) as tools that can facilitate the movement of information from short-term memory to long-term memory. Memory aids often combine memory strategies with visualization techniques. Our review of the literature showed some evidence that memory strategies may promote better levels of retention. For example, a study looking at retention found that soldiers better retain armour skills when they are encouraged to develop an organizational mental model of the task (Rowatt & Shlechter, 1993). This finding is in line with other researchers who have argued that connection to and integration of new information with other knowledge (see Andrews & Fitzgerald, 2010) will promote retention.

In general, retention seems to increase through techniques that require deliberate effort on the part of the student. How training programs could be designed to promote better levels of retention is an important goal of future research.

### 2.7.5 Emerging Research Themes and Questions – Skill and Knowledge Retention

This review of the skill retention literature suggests a number of key gaps in current knowledge and research about skill fading. A serious gap in the current literature is the lack of strong research depicting complex tasks, studied over a prolonged retention interval. Current literature is typically constrained to relatively simple tasks with limited retention intervals. It seems important for future research to promote better understanding about the retention of higher order cognitive skills (e.g., planning, problem solving and decision-making) after training, and to explore the retention of these skills over longer time frames.

Moreover, given the need to know how often to schedule refresher training, accurate prediction of retention levels for specific tasks is currently lacking. Although the U.S. military has developed the UDA model to do this, the status of this model in recent years is unclear, and there is little evidence in the available literature that it is currently in use. Moreover, as noted earlier this model does not appear to be particularly well-suited to complex tasks.

Another gap within the current body of knowledge that seems particularly relevant to training in the CF is the retention of collective skills. Given the need for many military teams to perform skills as a coherent unit, a critical issue is the retention of these skills. Unfortunately, this issue was reported to be particularly under-researched in a previous review (Adams et al., 2003), and there is little indication that more current research has worked to fill this void.

This review shows that the link between emerging technologies and skill retention is an in serious need of more empirical investigation. There is a clear assumption in the skill retention literature that technology could be used to help offset the loss of skilled performance. For example, a review of the literature exploring retention of armour skills (Rowatt and Shlechter, 1993, p. 11) concludes that future research should focus on "Examining the effectiveness of simulators and other automated training devices in augmenting skill retention". Given the increasing use of simulation within training systems, a critical question is the extent to which skills trained with simulators are subject to the same or different levels of decay. The retention of specific types of skill (e.g., procedural or more complex cognitive skills) being trained would also be critical to examine within this area of research. Technology might be helpful with working to design and present training materials in ways that research argues could offset skill decay. For example, given that mental models are argued to promote better levels of retention, designing simulations with the specific aim of building more complex mental models would be an obvious target of future research.

Within this area, there is a rich set of potential issues that would be possible to explore in future research and development efforts. Relevant research findings and possible research questions that emerge from the literature are shown in Table 8.

*Table 8 Findings and Research Questions- Skill Retention*

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| **Learning Factors and Retention** | |
| Individuals with higher cognitive ability show higher retention rates because they learn more (Rowatt & Shlechter, 1993). However, rates of decay are similar for all ability levels.<br>Expertise can increase the retention of new skills. | Does acceleration of learning impact negatively on retention?<br>What is the relationship between learner factors and retention factors?<br>What are the most critical student factors that impact retention of skills? |
| Training design - Retention is better when training more closely reflects the evaluated task.<br>Retention can be maximized by making training requirements functionally similar to on-the-job performance requirements (Rowatt & Shlechter, 1993).<br>Greater interference at time of learning (i.e., a random versus a blocked schedule) produced higher levels of retention and transfer (Goodwin, 2006). | Can increase contextual information (i.e., in rich simulation environments) promote higher levels of retention?<br>Can contextual interference while training facilitate higher levels of retention? |
| Refresher training - Length of time required for refresher training is less than 50% of the time required for the initial training.<br>Variable practice schedules enhance retention (Bryant & | What is the best trade-off between cost/risk for refresher training in a range of tasks?<br>Can ensuring testing and feedback soon after training facilitate improved retention? |

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| Angel, 2000).<br>Retention research concurs that students who were tested (and provided feedback on their degree of success) during training performed better at retention than those who received only presentation training (Bryant & Angel, 2000; Goodwin, 2006). | |
| Level of original learning is an excellent predictor of retention performance (Rowatt & Shlechter, 1993) | What is the best learning/retention trade-off? |
| Overlearning – Overlearning can promote better retention in some situations, but results are inconsistent. However, research has shown that 50% over-learning required to achieve positive effects for some skills (Bryant & Angel, 2000). | For what tasks/skills is overlearning effective?<br>Does overlearning impact individuals similarly?<br>Is overlearning cost effective? |
| Feedback - When feedback contains information about the magnitude and direction of performance errors the learner is directed toward correction, which can lead to better retention.<br>Feedback should be informative, but not become frequent enough to be a part of the students' mental representation of the task (Bryant & Angel, 2000). | Can the content of feedback be tailored (e.g., in automated systems) to facilitate better levels of retention? |
| Computer-assisted training can promote retention | Does computer-assisted training promote skill retention?<br>If so, is computer-based training effective for all learners and types of tasks? |
| Simulation-based training can promote retention - Technology may be particularly useful in circumstances where time resources are limited and brief episodes of skill performance can provide some form of practice that will help to retain competency (Andrews & Fitzgerald, 2010). | Does simulation-based training promote skill retention?<br>If so, is simulation-based training effective for all learners and types of tasks? |
| **Models of Skill Retention** | |
| A number of models have been developed to predict skill retention (Bryant & Angel, 2000).<br>Retention interval - Performance declines as the retention interval is increased (Semb et al., 1992; Bryant and Angel, 2000). The level of skill degradation depends on the type of skill | Can models of skills retention predict skill decay? |
| **Techniques for Retention** | |
| Stronger, more abstract and developed mental models can also increase retention of skills (Rowatt & Shlechter,1993)<br>Allowing learners to develop their own mnemonics enhances retention and transfer of procedural tasks (Druckman & Bjork, 1991; Wells & Hagman, 1991; cited in Rowatt & Shlechter, 1993). | What retention techniques are the most effective?<br>Can mental models improve rates of retention?<br>What kinds of tools/aids are most helpful for improving retention rates? Are there tools equally applicable to all tasks? |

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| Discrete procedural tasks (e.g., job knowledge) are more quickly forgotten than more complex continuous skills (Schaab and Dressel, 2001) (e.g., cognitive skills) | Can a predictive model depicting retention of varying types of skills be created? |

## 2.8 Critical Findings: Discussion and Emerging Themes

This review included 26 articles from three major bodies of literature, training, learning and retention. Our review of the literature suggests that there are many influences on the acquisition and retention of knowledge and skills. These include characteristics of the student, the instructor, and delivery media and methods used.

Our literature review showed that the construct of accelerated learning is still at a relatively early stage of development. Indeed, there is currently little that truly distinguishes the literature on accelerated learning from research that explores learning at a general level. The only discernable difference is that the accelerated learning and generic learning literature seem to use distinct terminology to describe similar principles of learning. Moreover, the accelerated learning concept is used by different parties for different purposes. The most relevant literature relevant to accelerated learning comes from the U.S. military domain (e.g., Andrews & Fitzgerald, 2010).

This work does provide general guidelines for accelerated learning, however this work has a more constrained scope in that it focused on the emergence of expertise within complex domains and learning principles rather than how learning of either simple or complex tasks can be more quickly (and better) facilitated.

Unfortunately, although the review clearly showed many different concepts as being relevant to accelerated learning and retention, research is not currently developed enough to provide any strong conclusions about relative importance of these concepts, or sets of factors, relative to each other (or even within a set). Looking at the many different approaches to training, for example, there is no clear answer about what factors are truly the most influential. Meta-analytic efforts to compare multiple factors do not appear to have emerged yet. This lack of clarity is the result of controlled research in these areas simply not having been directed specifically at the issue of promoting accelerated learning. The lack of systemization in the literature, and the inability to understand the effect of a variable in one setting on its performance in another is perhaps the key challenge in understanding the status of training in 2011.

Nonetheless, there was some agreement in the available literature about the issues and factors that influence learning and retention. Fourteen key concepts affecting learning and retention were identified from the literature review, as follows.

1. student attributes,
2. instructor attributes,
3. classroom aids and environment,

4. distance learning,
5. simulator-based instruction,
6. computer-based instruction,
7. collaborative learning
8. scheduling
9. feedback and testing,
10. adaptive instruction,
11. context and content,
12. learning factors and retention,
13. models of retention, and
14. techniques for retention.

Table 9 provides a summary of some of the relevant research findings noted in the literature and sample research questions that could be used to address some of the current gaps with each of these areas.

*Table 9 Summary of Findings and Research*

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| **Student Attributes** | |
| Student attributes impact on learning | What student attributes are most critical to learning?<br>What is the relative importance of student attributes relative to other sets of factors (e.g., delivery media)? |
| Cognitive ability promotes learning (Salas & Cannon-Bowers, 2001) | How can learning be optimized for individuals with low cognitive abilities? |
| High motivation to learn increases learning (Blume et al., 2010; Meier, 2000). Hands-on experience can increase motivation.<br>Understanding relevance of training can increase motivation to learn application of newly learned skills. (TLC, 2010; Zipperer et al., 2003). | How can training be designed to maximize student motivation?<br>What approaches and technologies (e.g. virtual worlds) best promote immersion, engagement, social presence, how best to promote "flow"<br>Embodiment, presentation and engagement (physical representation of the user, e.g., fidelity of the avatar) |
| Learning styles may influence learning | Should learning styles be further investigated? |
| Prior knowledge or experience can improve learning (e.g., computer background knowledge has an impact on training and retention of digital skills (Goodwin, 2006). | How can prior knowledge and experience be brought to bear on training effectiveness? |
| Level of comfort with technology can slow or increase learning and motivation to learn when using technological tools (Capuzzi Simon, 2007; Zipperer et al., 2003)Expertise improves learning (Andrews & | How does experience and comfort with technology impact on learners in technology-based training? What compensatory approaches might support personnel with low levels of experience? |

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| Fitzgerald, 2010) | How can training build expertise more quickly?<br>How can expertise best be leveraged?<br>Can emerging technologies support the emergence of expertise? |
| **Instructor Attributes** | |
| Instructor attributes (e.g., subject matter expertise, teaching experience and teaching style) impact on learning | What are the most critical aspects of instructor effectiveness?<br>What is the ideal mix of subject matter expertise and teaching experience?<br>What makes a good mentor? |
| **Delivery Media - Classroom Aids and Environment** | |
| Receptive, behavioural, guided discovery, exploration<br>Problem-solving focused training increases learning transfer (Schaab & Dressel, 2001)<br>Lecture-based instruction is found to be less favourable by many students (Schaab & Dressel, 2001) and ineffective in terms of accelerating learning (Meier, 2000) | What training approaches can help to accelerate learning? |
| Promoting visualization/development of mental models promotes learning<br>Novices tend to have mental models reflective of surface features while experts have more abstract mental models that prove more effective in performance (Schumacher & Czerwinski, 1992; cited in Andrews & Fitzgerald, 2010).<br>Visual learning techniques tend to be more effective than verbal learning techniques regardless of the preferred learning style (Pashler et al., 2008). | How can the emergence of mental models be supported by training techniques?<br>Do rich mental models promote accelerated learning?<br>Are mental models equally relevant to improving training effectiveness in varying skill domains? |
| Specific classroom-aids<br>"Hip pocket" training – impromptu training, short 15-20 minute lessons between the "cracks" (e.g., compass training during a water break while on a hike).<br>Concept maps (mind-mapping), flow diagrams, music, "serious" games | What aids are most conducive to learning?<br>Do these largely untested training aids (e.g., hip pocket, concept maps) promote accelerated learning? |
| Positive learning culture can foster effective learning (see Blume et al., 2010; Meier, 2000)<br>Learning transfer is significantly impacted by the transfer climate (Blume et al., 2010).<br>All 5 senses should be stimulated in order to achieve holistic learning (Meier, 2000; TLC, 2010). Overstimulation or unpleasant stimulation should be avoided (Erickson, 1991). | What aspects of the training environment most influence learning effectiveness? |
| Games provide novel and/or motivating methods of learning (Erickson, 1991; Cannon-Bowers & Bowers, | What technology has been used to provide effective gaming-based training that has led to accelerated learning? |

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| 2008). | What gaming-based technologies could be implemented to accelerate learning within the CF? |
| **Delivery Media - Distance Learning** | |
| Optimal distance learning may depend on type of skill/knowledge, resources, and additional responsibilities of the instructor and student. | What skills are most conductive to the use of distance education?<br>Do skills taught via distance education show similar rates of decay? |
| **Delivery Media – Simulation-Based Instruction** | |
| Students who are exposed to and participate in immersive training learn faster and more effectively (see Meier, 2000).<br>Simulations can be used to create realistic, near transfer type training programs which is one method used to accelerate learning (see Cannon-Bowers & Bowers, 2008; Zipperer et al., 2003)<br>Simulations enable time compression required for accelerated learning (Hoffman, Feltovich, Fiore, Klein, & Zeibell, 2009) | How much fidelity is enough?<br>What aspects of fidelity are most critical to enabling accelerated learning (e.g., contextual embeddedness, tailoring to the individual)?<br>What trade-offs can be made between simulation-based instruction and actual practical tasks (e.g., flight time, range time, sea time)?<br>Does simulation-based training accelerate learning?<br>How can simulation-based training be used to tailor training to the needs of the individual?<br>Do all types of learners benefit equally from simulation-based training?<br>Does simulation-based training facilitate better transfer than conventional training to real-world contexts? |
| Technology can be implemented to facilitate training of geographically distributed students and instructors (see Cannon-Bowers & Bowers, 2008; Capuzzi Simon, 2007) | In team environments, can simulated-based instruction models substitute for team members?<br>How can simulation-based training be used to tailor training to groups and teams?<br>Can simulation-based training accelerate learning at the team level? |
| **Delivery Media - Computer-Based Instruction** | |
| Computer-based instruction (ranging from very simple to very complex tutoring systems) can promote higher levels of learning. For example, web-presented information significantly increased test scores compared with scores for control group (lecture style) (Cannon-Bowers & Bowers, 2008). | Can computer-based training accelerate learning?<br>Can computer-based training facilitate better levels of transfer to work performance?<br>What forms of computer-based instruction are most likely to help accelerate learning?<br>How does computer-based training relate to transfer to real-world contexts?<br>Do intelligent tutoring systems work better if they are tailored to the needs of the individual?<br>Are there means to accelerate learning through capitalizing on informal learning (vs. formal) using computer-based and technology-based information? |

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| **Delivery Methods – Collaborative Learning** | |
| Collaborative tools can promote better learning | Do collaborative tools promote learning?<br>What collaborative technologies show the most promise of promoting accelerated learning?<br>What collaborative technologies might be used in training to promote accelerated learning (e.g. Facebook, Twitter, and SMS)?<br>How do distributed teams learn most effectively? |
| Collaborative training can promote learning. Collaboration among students can provide different perspectives and enrich the learning experience (see Schaab & Dressel, 2001), | What types of skills are most conducive to collaborative benefits during training? |
| **Delivery Methods-Scheduling** | |
| Practice - Need to constantly "stretch" skills to have accelerated learning – need to have increasing levels of difficulty<br>Spaced practice was more effective than massed practice in learning complex, cognitive skills (Andrews & Fitzgerald, 2010). Procedural skills can benefit from mass training (e.g., hours of repetition) (Zipperer et al., 2003) | How should practice be scheduled (spaced or massed) for varying types of skills?<br>What is the relative effectiveness of different training schedules?<br>What kinds of "stretching" of skills are optimal (e.g., complexity, rates, duration, unique challenges). What are the ideal rates of "stretching"?<br>What training technologies are most helpful in providing practice that "stretches" skills sets, can be tailored to the performance of the individual? |
| Training design - Evidence supports front loading mass-instruction (high frequency) for procedural skills (see Zipperer et al., 2003) | How should training be designed to accelerate learning within specific skill areas? |
| **Delivery Methods – Feedback and Testing** | |
| Feedback - Immediate feedback during training /performance is most effective (Lajoie, 2003; cited in Andrews & Fitzgerald, 2010; Semb et al. 1992)<br>Feedback can be provided by the instructor or peers (i.e., tutoring) (see Schaab & Dressel, 2001; Zipperer et al., 2003) | What are the optimal rates of feedback?<br>What are the optimal rates of testing?<br>Does feedback help to accelerate learning, and if so, how?<br>Does real-time feedback to trainers of student understanding (e.g. use of clickers in the classroom) help to accelerate learning?<br>Do instructor and system feedback have the same effects? |

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| **Delivery Methods – Adaptive Instruction** | |
| Learning should be tailored to individuals<br>Personalized training is more interesting, easier, increases motivation and consequently increases learning (see Andrew & Fitzgerald, 2010; Meier, 2000) | What types of adaptive instruction are most critical to promoting accelerated learning (e.g., rate of presentation, practice)?<br>Dynamic remediation - What training technologies provide the best flexibility for promoting tailoring of instruction (e.g. |

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| Low-ability students benefit from highly-structured learning environments and high-ability students benefit from low-structured learning environments (Pashler et al., 2008) | computer-based tutors)?<br>How can technology be designed to maximize responsiveness to the student?<br>How can neuroscience best be applied to military teams? |
| Instructors - Matching supervisory styles with the capabilities and commitment of the student can result in more effective training (Hersey & Blanchard, 1977) | What instructor behaviours facilitate accelerated learning?<br>How does the level of instructor training and expertise influence learning? What aspects of their expertise are most critical to maximal learning? |
| **Delivery Methods – Context and Content** | |
| Contextual embeddedness improves learning (Meier, 2000) | Can overlearning help to accelerate learning?<br>How much stress is pest?<br>Is cross-training a good method of promoting learning and retention?<br>What forms of contextual learning are most advantageous?<br>What technologies best support contextual embeddedness? |
| Using principles (why training is necessary) create foundational knowledge that improves learning (Meier, 2000) | Does presentation of background and principles promote accelerated learning?<br>What are the time/efficiency trade-offs for accelerated learning? |

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| **Learning Factors and Retention** | |
| Individuals with higher cognitive ability show higher retention rates because they learn more (Rowatt & Shlechter, 1993). However, rates of decay are similar for all ability levels.<br>Expertise can increase the retention of new skills. | Does acceleration of learning impact negatively on retention?<br>What is the relationship between learner factors and retention factors?<br>What are the most critical student factors that impact retention of skills? |
| Training design - Retention is better when training more closely reflects the evaluated task.<br>Retention can be maximized by making training requirements functionally similar to on-the-job performance requirements (Rowatt & Shlechter, 1993).<br>Greater interference at time of learning (i.e., a random versus a blocked schedule) produced higher levels of retention and transfer (Goodwin, 2006). | Can increased contextual information (i.e., in rich simulation environments) promote higher levels of retention?<br>Can contextual interference while training facilitate higher levels of retention? |
| Refresher training - Length of time required for refresher training is less than 50% of the time required for the initial training.<br>Variable practice schedules enhance retention (Bryant & Angel, 2000). | What is the best trade-off between cost/risk for refresher training in a range of tasks?<br>Can ensuring testing and feedback soon after training facilitate improved retention? |

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| Students who receive both feedback and testing perform better than with only presentation training (Bryant & Angel, 2000; Goodwin, 2006). | |
| Level of original learning is an excellent predictor of retention performance (Rowatt & Shlechter, 1993) | What is the best learning/retention trade-off? |
| Overlearning – Overlearning can promote better retention in some situations, but results are inconsistent. However, research has shown that 50% over-learning required to positive effects for some skills (Bryant & Angel, 2000). | For what tasks/skills is overlearning effective?<br>Does overlearning impact individuals similarly? |
| Feedback - When feedback contains information about the magnitude and direction of performance errors the learner is directed toward correction, which can lead to better retention. (Bryant & Angel, 2000). | Can the content of feedback be tailored (e.g., in automated systems) to facilitate better levels of retention? |
| Computer-assisted training can promote retention | Does computer-assisted training promote skill retention? If so, is computer-based training effective for all learners and types of tasks? |
| Simulation-based training can promote retention - Technology may be particularly useful in circumstances where time resources are limited and brief episodes of skill performance can provide some form of practice that will help to retain competency (Andrews & Fitzgerald, 2010). | Does simulation-based training promote skill retention?<br>If so, is simulation-based training effective for all learners and types of tasks? |
| **Models of Skill Retention** | |
| A number of models have been developed to predict skill retention (Bryant & Angel, 2000).<br>Retention interval - Performance declines as the retention interval is increased (Semb et al., 1992; Bryant and Angel, 2000). The level of skill degradation depends on the type of skill | Can models of skills retention predict skill decay? |
| **Techniques for Retention** | |
| Stronger, more abstract and developed mental models can also increase retention of skills (Rowatt & Shlechter,1993)<br>Allowing learners to develop their own mnemonics enhances retention and transfer of procedural tasks (Druckman & Bjork, 1991; Wells & Hagman, 1991; cited in Rowatt & Shlechter, 1993). | What retention techniques are the most effective?<br>Can mental models improve rates of retention?<br>What kinds of tools/aids are most helpful for improving retention rates? Are there tools equally applicable to all tasks? |
| Discrete procedural tasks (e.g., job knowledge) are more quickly forgotten than more complex continuous skills (Schaab & Dressel, 2001) (e.g., cognitive skills) | Create a predictive model depicting retention of varying types of skills be created? |

Given the results of the literature review, then, it was important to work with subject matter experts in training and/or learning and to further explore the meaning, implications and importance of these topic areas from their perspectives. Eliciting their views was critical to identifying the most important topics to be pursued in future research and development efforts undertaken by DRDC and CDA. This workshop is further detailed in subsequent sections.

# 3 Accelerated Learning and Retention Workshop

## 3.1 Introduction

This section describes the results of a workshop conducted by the CDA and DRDC. The objectives of the workshop were to prioritize the topics identified in the literature review, and to understand how stakeholders involved in CF training view the requirements of future research and development efforts.

The outcomes will be used to formulate an ARP proposal(s) that will analyse, design, develop and assess instructional approaches, technologies, strategies and interventions that have most promise for reducing learning times and ensuring maximal retention within the CF.

## 3.2 Methods

A one-day workshop was held to explore the 15 final topics that emerged from the literature review with stakeholders. This section details the stakeholders who participated in the workshop, the schedule, and the method used to conduct the workshops.

### 3.2.1 Participants

Stakeholders who participated in the prioritization workshop were selected by CDA and DRDC. They were chosen on the basis of their involvement, expertise and/or interest of the CF training system. Participants were from organizations and agencies including DRDC, CDA, Royal Military College of Canada (RMCC) as well as other Canadian Forces organizations spanning all three environments (air, maritime, land).

### 3.2.2 Location and Schedule

The workshop was conducted in Kingston, Ontario on the campus of the RMCC. Afternoon activities were held at the CDA also on the RMCC campus. All materials for the group activity sessions (matrices for rating topics, paper, and markers) were provided by CDA facilitators.

The workshop followed a structured schedule, running from 0800 to 1600 with a 1 hour lunch break and two 15-minute coffee breaks. The agenda that was sent out to attendees is shown in Table 10.

*Table 10 Workshop Schedule*

| Time | Workshop Phase | Event | Speaker |
|---|---|---|---|
| 0800 | Phase 1 | Workshop Introduction | LCdr Peter Ball, CDA |
| 0815 | | Guest Speaker Introduction | Dr. Lochlan Magee, DRDC |

| Time | Workshop Phase | Event | Speaker |
|---|---|---|---|
| 0820 | Phase 2 | Perspective on Accelerated learning | Dr. Dee Andrews, USAF Research Laboratory |
| 0835 | Phase 3 | Keynote Address – Accelerated learning | Dr. Robert Hoffman, Florida Institute for Human and Machine Cognition (FIHMC) |
| 0910 | Phase 4 | Presentation of topics emerging from literature review | Dr. Barbara Adams, Humansystems Inc. |
| 1025 | | REFRESHMENT BREAK | |
| 1040 | | Presentation and Discussion of Criteria | Dr. Lochlan Magee, DRDC<br>LCdr Peter Ball, CDA |
| 1100 | Phase 5 | Dry Run<br>A dry run the afternoon's prioritization process will be conducted (or the first topic conducted together). | Capt. John Wyville, CDA |
| 1200 | | LUNCH BREAK | |
| 1300 | Phase 6 | Break-out Group Activity<br>Each group will use the criteria to score the topics and prioritize them to the 5 strongest. | Group Facilitators, CDA |
| 1530 | Phase 7 | Workshop Summary<br>After a brief break where the group facilitators will consolidate the results the group will reconvene. A presentation will be given on the results of the breakout groups and the overall 5 strongest topics selected. | LCdr Peter Ball, CDA<br>Dr. Lochlan Magee, DRDC |

This agenda was followed during the workshop, with some minor variations in time. The seven phases of the workshop are detailed in the sections that follow.

#### 3.2.2.1 Phase 1 – Workshop Introductions and Guest Speaker Introductions

LCdr Peter Ball provided a brief introduction of the purpose and objectives of the current work and associated workshop. This time also included an overview of the day's agenda, schedule and administrative details (e.g. location of facilities, emergency exits, etc.). The full introductory presentation is available in Annex A-Workshop Introductions .

Dr. Lochlan Magee introduced the guest speaker (Dr. Dee Andrews) and keynote speaker (Dr. Robert Hoffman); he provided a description of their expertise and relevant work.

#### 3.2.2.2 Phase 2 - Guest Speaker Presentation: Dr. Dee Andrews

Dr. Dee Andrews, a senior scientist in the Human Effectiveness Directorate Air Force Research Laboratory (U.S. AFRL) connected remotely to provide a presentation on his work related to accelerated learning. His current work at the U.S. AFRL demonstrates that accelerated learning has been recognized as an important topic in improving military training and consequently performance. Dr. Andrews has taken the lead in conducting this research working with a team of researchers including Dr. Robert Hoffman.

Dr. Andrews argued that current warfighters are often required to perform complex tasks under time pressure, even when they are not particularly well trained. Irregular warfare (IW), counterinsurgency (COIN), and Stability, Security, Transition, Reconstruction Operations (SSTRO) demand "real-time situational understanding". Dynamic planning skills (including both kinetic and non-kinetic skills) and interpersonal skills are particularly difficult skills to learn. Dr. Andrews identified a number of accelerated learning challenges that are not well funded. These include understanding proficiency requirements and how to achieve accelerated learning, how to increase retention, and how to calculate a cost/benefit analysis when implementing accelerated learning. Accelerated learning requires constant "stretching" of the skill, high levels of intrinsic motivation, enriched practice with meaningful feedback, mentoring, adapted (or tailored) practice that matches unique learning styles, the concept of scheduling (optimal spacing of materials), testing used in learning, self-explanation, and learning through comparison. Dr. Andrew identified a number of techniques for accelerating learning emerging from the cognitive science literature such as spacing of practice, using tests to promote learning and use of deep principles. Thus far, Dr. Andrews and colleagues have generally found positive, successful results from their research. He recognized that specific training activities such as "Think like a Commander" have demonstrated the ability to compact years of military experience and training into a few weeks. The approach requires students to think through highly complex scenarios reflective of realistic military encounters. Solving problems within multiple realistic situations within a few weeks provides experience that would normally take years to accumulate. In addition to the successes, a number of paradoxes exist. First, accelerated learning may adversely affect retention, so it will be important to find the best possible balance between the two. Second, accelerated learning in one area may have negative consequences for generalization to a different situation. Lastly, accelerated learning through means of shorter/faster training may result in lack of readiness for task performance. Much investigation is required to attain accelerated learning within the military domain; in particular research of longitudinal and long-term retention studies, attention to policy issues within the military, and funding for long-term programs. See Annex B- Guest speaker presentation: Dr. Dee Andrews for the full presentation.

#### 3.2.2.3 Phase 3 - Keynote Address: Dr. Robert Hoffman

Dr. Robert Hoffman was invited as the keynote speaker. As a world leader in the field of cognitive systems engineering and Human Centered Computing (HCC), Dr. Hoffman has made significant contributions in a number of research areas, including human factors in remote sensing, the psychology of expertise and use of cognitive task analysis, and on intelligent systems technology and the design of macrocognitive work systems. He is currently working as a senior research scientist at the Florida Institute for Human and Machine Cognition (FIHMC) in Pensacola, Florida. Dr. Hoffman has been working with Dr. Andrews and a team of researchers in investigating accelerated learning.

Dr. Hoffman presented on the topic of accelerated learning highlighting the problem space, challenges, paradoxes, potential solutions and issues. He argues that the push to understand how to accelerate learning stems from the need to know how to build expertise more quickly (in order to escape the "ten-year rule") and to understand how to rapidize the re-acquisition of skills that have faded. The need is to have experts in their field be able to make fast decisions, to resolve tough problems using good judgment, and to anticipate future problems. As Hoffman argues, they must "…exercise effective technical leadership in ambiguous situations". However, the acquisition of expertise usually takes years. Within a military context, factors such as collateral assignment, redeployment (after time without training), inadequate mentoring and "just-in-time training" (rather than continual training) present additional challenges to high proficiency. Dr. Hoffman also noted that there are multiple meanings of accelerated learning, including rapidized training (while ensuring its effectiveness), rapidized knowledge sharing (moving lessons learned in battlespace into training) and accelerated proficiency. Accelerated learning is relevant in many different domains, including cultural awareness and understanding, second language learning, piloting and personnel management. Dr. Hoffman indicated a number of success stories, namely intelligent tutoring systems, Top Gun and successes in simulation-based training. He then indicated a number of relevant research results showing ways to improve training. Specifically, it is more effective when combined with considerable practice in scenarios or with realistic examples, and when outcome and process feedback are provided at critical stages. Tough problems and mentoring can also help to advance learning. In terms of retention, Dr. Hoffman indicated the benefits of spacing of practice, particularly when practice on the target task is interspersed with other tasks. Overlearning is also identified as a prime determinant of memory and skill decay. However, he also noted that the effects noted in the literature are often contradictory, so generalizations are difficult. A particular challenge in judging the effectiveness of training interventions is intermediate causation, and the fact that there is always a complex set of interacting factors that impact on outcomes. Dr. Hoffman indicated that some paradoxes are also relevant to accelerated learning. Specifically, the paradox of jobs is that the nature of work constantly changes, so learning and re-learning is always necessary. However, the most highly skilled personnel are often moved to other positions. The paradox of tasks is that they are often conceptualized as discrete and sequential, but they are actually context-dependent.

In his summary, Dr. Hoffman addressed several questions. He argued that learning can be accelerated for fixed tasks and probably for dynamic tasks. Research is currently unclear about whether accelerated learning penalizes retention on its own or after hiatus. Requirements for future research are better methods for cognitive task analysis, addressing the challenge of the pace of change in professions practice (e.g., military jobs), and better understanding the potential contribution of mentors. Other methodological research needs include understanding the impact of "booster sessions" on retention, differential decay rates, and ways to rapidly update skills to prevent decay. Dr. Hoffman also identified several acceleration methods, including technologies such as computer games and simulations, case-based instruction, corrective feedback and tough-case time compression. Lastly, he identified several areas that are the most important priorities for research and development. These include longitudinal studies, dynamic tasks and challenges, domains with civilian analogs, and integrated knowledge management components. Research that targets achievement of proficiency (particularly in the apprentice to senior journeyman level), helps to understand the retention of expertise at the level of personnel as well as incorporated organizational knowledge, and with application to the military domain are also important priorities. More specific details of the presentation can be found in Annex C- Keynote address: Dr. Robert Hoffman.

#### 3.2.2.4 Phase 4 - Presentation of Topics

Dr. Barbara Adams, part of the HSI® research team, presented fifteen research topics that emerged from the literature review and subsequent conversations. Fourteen topics were identified in the review. The Embedded Training topic was added after consultation with the SA and TA. Each topic was defined and presented with paradigmatic research questions. These topics were divided into learning and retention categories, as follows:

**Learning Topics**

1. Student attributes
2. Instructor attributes

Delivery Media

3. Classroom aids/ environment
4. Distance learning
5. Computer-based instruction
6. Simulator-based instruction
7. Embedded training

Delivery Methods

8. Collaborative learning
9. Scheduling
10. Feedback and testing
11. Adaptive instruction
12. Context and Content

**Retention Topics**

13. Relationships to learning factors
14. Models of knowledge /skill retention
15. Techniques for Retention

For the full presentation see Annex A.

#### 3.2.2.5 Phase 5 - Dry Run

Captain John Wyville provided an overview of the afternoon break-out group activity. The dry run involved a brief discussion and mock rating. The participants were informed that the break-out sessions would involve a brief discussion on each topic in order to share their expertise and perspectives followed by completion of a matrix including ratings, ranking and comments for each of the 15 topics.

Participants were provided an opportunity to briefly discuss the topic of 'student attributes' as an example discussion. Following the discussion, Captain John Wyville demonstrated how participants would complete each rating using large print-outs of the rating matrix.

Rating criteria were explained as well as each of the 15 evaluation criterion. The rating scale to be used ranged between 1 (strongly disagree) and 5 (strongly agree) with 3 (neither agree nor disagree) as the midpoint. Participants were asked to use an asterisk (*) for 'do not know' if they were unable to rate topic areas (e.g., due to lack of knowledge or experience). The 15 evaluation criteria were provided by DRDC and CDA to reflect the criteria used to evaluate ARP proposals within the DRDC system. The criteria presented by the facilitator were as follows:

A. The topic has scientific merit.

B. The topic is novel or innovative in addressing learning and retention.

C. The topic aligns with and supports CF/DND goals.

D. The topic will have wide application within CF/DND.

E. The topic will improve organizational efficiency and/or effectiveness.

F. The topic will address identified gaps - learning and retention deficits - in the CF/DND.

G. The anticipated results of addressing the topic will accelerate learning and/or improve retention.

H. The anticipated results will be relatively easy to implement.

I. National or international collaboration on this topic is possible.

J. The topic will attract an industrial stakeholder for R&D.

K. There is sufficient capability and/or capacity within Canada to take on this topic for R&D.

These criteria were presented in the matrix that participants were required to complete during the afternoon breakout sessions. After ranking each of these criterion, participants were also required to calculate a total (sum of all ratings), and provide the number of criteria for which they had provided a score (i.e., excluding columns with asterisks). A column for "rank" was also included in the spreadsheet, and participants were expected to rank the importance of the topics from their unique perspective. This would provide another way of comparing the relative importance of the topic areas. Lastly, a column for participant comments was also included in the matrix.

#### 3.2.2.6 Phase 6 - Break-out Group Activity

The afternoon sessions began with a brief introduction and recap of the task. In all, thirteen participants were divided into 1 of 3 groups by the primary CDA facilitator, resulting in one group of two participants, a group of five, and a group of six participants. These groups were each lead by a CDA facilitator, and discussion centred on each of the 15 topics identified as potentially relevant to learning and retention. Following the discussion of each topic, participants were asked to complete the matrix by rating each topic area on each of the evaluation criteria.

Two participants left during afternoon session due to prior commitments, leaving one group of five, a group of two, and a group of four. All participants completed ratings prior to leaving the workshop. CDA facilitators ran each of the groups allowing time for discussion on each topic and

to complete ratings. Participants were encouraged to write on their matrices all comments and potential research questions that came up during discussion.

One HSI® researcher accompanied each break-out group to collect detailed notes of the discussion, and to provide definitions of each of the topics as necessary.

#### 3.2.2.7 Phase 7 - Workshop Summary

After completion of the break-out sessions, all remaining workshop participants reconvened in a common room. Participants' matrices (with completed topic ratings on the evaluation criteria) were collected by CDA facilitators, and analyzed in a preliminary assessment. As a conclusion to the workshop, participants were brought together to discuss general thoughts on the 15 research topics, evaluation criteria, and their overall experience in the workshop.

After the workshop, the data was collected and further analyzed by HSI® researchers. Qualitative analyses focused on bringing together the group discussions that had occurred during the break-out sessions. Quantitative analyses focused on the ratings and rankings of each of the 15 topics, as well as ratings of the evaluation criteria.

## 3.3 Results

This section details the results of the accelerated learning workshop. This section begins with an overview of some of the limitations of the workshop. Any scientific activity in applied settings is subject to challenges and limitations. As some of the challenges faced during the workshop impact substantively on the results and their interpretation, it seems important to explore these before the rich qualitative analyses and quantitative results.

### 3.3.1 Limitations

The results of this workshop are limited in several ways. As it was necessary to postpone and reschedule, workshop attendance was significantly lower than initial projections. Due to prior commitments, some participants who attended the morning session were not able to attend the afternoon. Two participants also needed to leave during the afternoon sessions. Fortunately, these two participants completed their ratings prior to their departure. Although the workshop provided rich information, the small sample size (n = 13) limits the analyses that can be meaningfully conducted on these data, and may limit the generalizability of the results.

Missing data also limits the strength of the conclusions that can be draw from the workshop results. Participants were unable to provide ratings for many of the items. An analysis of the missing data showed that of the possible 2145 data points (ratings by 13 participants on 15 topics, and 11 evaluation criteria), 10% of these data points did not receive ratings from participants.

Further analyses were conducted to better understand these missing data at the topic level, as shown in Table 11.

*Table 11 Missing data – topics*

| | | # Missing ratings | % Missing |
|---|---|---|---|
| Student attributes | | 13 | 9.1% |
| Instructor attributes | | 10 | 7.0% |
| Delivery media | classroom aids and environ | 8 | 5.6% |
| | distance learning | 4 | 2.8% |
| | computer-based instruction | 9 | 6.3% |
| | simulator-based instruction | 3 | 2.1% |
| | embedded training | 14 | 9.8% |
| Delivery methods | collaborative learning | 16 | 11.2% |
| | scheduling | 28 | 19.6% |
| | feedback and testing | 16 | 11.2% |
| | adaptive instruction | 10 | 7.0% |
| Content and context | | 14 | 9.8% |
| | relation to learning | 48 | 33.6% |
| | models of skill retention | 11 | 7.7% |
| | techniques for retention | 12 | 8.4% |

As Table 11shows, then, missing data were more common for topics that participants had reported having difficulty understanding, namely, the scheduling and relation of retention to learning factor topics. Further analyses explored missing data at the participant level, and showed that missing responses varied from 3% to 22% among participants.

Lastly, missing data for the evaluation criteria were also analysed. Missing responses by evaluation criterion are shown in Table 12.

*Table 12 Missing data- evaluation criteria*

| | # Missing ratings | % Missing |
|---|---|---|
| A – The topic has scientific merit. | 6 | 3.2% |
| B – The topic is novel or innovative in addressing learning and retention. | 5 | 2.6% |
| C – The topic aligns with and supports CF/DND goals. | 16 | 8.5% |
| D – The topic will have wide application within CF/DND. | 9 | 4.8% |
| E – The topic will improve organizational efficiency and/or effectiveness. | 14 | 7.4% |
| F – The topic will address identified gaps - learning and retention deficits - in the CF/DND. | 28 | 14.8% |
| G – The anticipated results of addressing the topic will accelerate learning and/or improve retention. | 10 | 5.3% |
| H – The anticipated results will be relatively easy to implement. | 17 | 9.0% |
| I – National or international collaboration on this topic is possible. | 24 | 12.7% |
| J – The topic will attract an industrial stakeholder for R&D. | 45 | 23.8% |
| K – There is sufficient capability and/or capacity within Canada to take on this topic for R&D. | 42 | 22.2% |

This analysis is again consistent with participants' comments in the AAR (Section 3.3.4) noting that some of the evaluation criteria were particularly difficult for them to know how to rate (i.e., J, K). Due to the complexity of the research literature, the topics were necessarily broad and often multidimensional. Participants noted that it was difficult to know how to rate a topic on a given criterion, as they would rate the multiple facets of a topic differently. Since their specific mental models of the topic were not considered, it was unclear which specific aspect of a complex topic actually influenced their ratings. As a whole, then, participants seemed to err on the side of caution if they were unsure about how to rate the required elements. Although this missing data makes it difficult to do extensive analyses on this limited data set, the ratings that they did provide hopefully reflect their clear areas of experience and expertise with low levels of speculation.

The lack of consistency within the breakout group discussion is a potential limitation. Participants were provided with general instructions as a large group; however, there was little consistency in terms of how the break-out groups were conducted. Hence, participants might have had different experiences. For example, ensuring that participants understood exactly how the terms were being defined occurred differently within the 3 groups, and this could have impacted how ratings were completed. As discussed in Section 3.3.2 below, for example, one group was left to discuss topics as they naturally evolved, rather than the other two groups where the facilitator actively promoted discussion and progressed through topics systematically.

It might also have been helpful to have some background information about participants, and to understand their particular stake and expertise in the workshop topics. Given the apparent differences in facilitation style within the break-out groups, it might have been helpful to evaluate how ratings related to group membership and to the experiences within the group. However, which questionnaires belonged to which group members was unknown. Lastly, having all groups work through the topics in the same order might have resulted in the early topics getting considerably more discussion than later topics, due to either time constraints or participant fatigue. The amount of discussion with later topics seemed to have diminished somewhat as groups worked through the topics.

Of course, it is important to note that any applied research effort is likely to face challenges, and that there is no way to know the extent to which these limitations impacted the results (if at all). Comments from participants in the after action review were strongly supportive of this workshop, and it did elicit important discussion and debate about the most critical factors related to learning and retention. As such, even with the potential limitations, this research provided a good empirical base for advancing these topics in future research and development efforts.

### 3.3.2 Qualitative Results

Some general observations seem important to understanding the rich data that emerged from the breakout group discussions. At the start, the breakout groups received somewhat different instructions. One group was instructed that the 15 topics should be considered in the light of relevant implementation within the CF, as well as to include multigenerational learners (e.g., 17-55 years old), different experiences and different learning styles. The second group was provided encouragement to discuss each topic as it best related to CF training in general. Participants in the third and final group were provided little instruction other than being encouraged to talk about topics as they saw fit. A novel approach taken by one of the facilitators was to combine some of

the topic areas during the discussion (e.g., simultaneous discussion of student attributes and instructor attributes and talking about the issue of retention as a whole).

Within 2 groups, facilitators guided participants to move from topic to topic, whereas discussion in the 3rd group was guided by the two participants. As groups shifted to new topics within the 2 groups, Humansystems® observers recorded the amount of time spent on each topic within the available 2 groups. Discussions on topics ranged from 0 (i.e., some topics received no discussion due to time constraints) to 15 minutes, with an average of 6 minutes on each topic.

During discussions, groups often requested definitions of the topics, and these were provided by Humansystems® observers based on the PowerPoint presented by Humansystems® in the morning session (Annex D- Presentation of topics).

#### 3.3.2.1 Student attributes

As noted in the literature review, prominent dimensions of student attributes encompass cognitive ability, motivation, learning styles, and prior knowledge or experience (e.g., training and education).

As participants discussed student attributes, they noted that this was a broad topic that encapsulated social phenomenon (i.e., culture, generational differences), technology, individual characteristics (i.e., motivation, individual variation, ADD), and program development (i.e., target audience).

First, participants discussed how social phenomenon such as culture could be leveraged to accelerate certain types of training. Also, participants noted that with an increase in technology, the style, and pace of learning have dramatically increased among younger generations. Multi-tasking may, in some cases, be required in order to keep the attention of today's youth.

Further, participants noted that training specific technology has significantly developed over the past 20 years. Familiarity with social media and comfort with technology differs among generations. How technology should be implemented would naturally need to vary depending on the target generation, and they noted that this issue warrants further research. They further noted that although there is some research available on these topics, very little is related to military training in general, and specifically to the CF.

In addition to social phenomenon, individual characteristics were discussed. Motivation was recognized as being vital to accelerate learning and increase retention by two of the three groups. Participants were interested in discussing potential factors that influence high motivation. It was suggested that factors within the training program or environment (e.g., instructor attributes, or technology) may influence trainees' motivation. One method to increase trainee motivation could be to focus on career planning as motivation. For example, allowing trainees to have more influence over their pay grades, promotions, and/or postings based on success or achievement in training programs. Participants voiced concern that implementation of such programs may be significantly affected by the systemic or organizational limitations (and vice-versa).

The role of student attributes in training preparations was also discussed. Notably, in the design phase of creating training programs, some participants noted that target audiences are not often

taken into account. The variation among trainees may be too large to consider when developing a course. Questions were raised as to how one would make a training program more flexible in order to accommodate a wide range of student attributes. The current system does not take trainees' previous experiences or special needs (e.g., attention deficit disorder) into account. Trainees who start with transferable skills may be able to move through training at a quicker pace, or start further along in the training. Individuals who have special needs may require additional effort and time in certain areas in order to achieve proficiency and retain knowledge and information. Developing specific training regimes and programs is expected to require significantly more effort, which would in turn require additional resources on the part of the developers, instructors, and /or trainees. Participants noted that it would be important to consider CF training as adult learning in a system where personnel have additional responsibilities and commitments outside a training program (e.g., duties, families).

A final comment noted by participants was that the current programs may train in particular ways that have not been assessed or validated. For instance, CF often provides background information to trainees prior to the start of a training course. A pre-course reading package is intended to bring trainees up to a particular level prior to the start of the course. However, there is currently no empirical evidence that confirms that this information is actually helpful.

Research questions relevant to student attributes during the break-out discussions are shown in Table 13.

*Table 13 Student attributes- Research questions*

| Research Topic | Research Questions |
|---|---|
| Student attributes | Can cultural differences be utilized to accelerate certain types of training?<br>• Does multitasking improve overall productivity for the new generation?<br>  o If informal learning takes place in multitasking environments, what are the effects on retention?<br>• What causes high motivation? Is it the student's intrinsic motivation, influence of the instructor, or classroom aids?<br>• How does accounting for student attributes in practice schedules influence training effectiveness? |

#### 3.3.2.2 Instructor attributes

Instructors have a key role to play in training. Instructors are obviously very diverse, and factors such as their subject matter expertise, their experience as a teacher and their style of teaching emerged from the literature review as important instructor attributes.

Group discussions about instructor attributes focused on the ability to teach effectively, teaching style and preferences, and operational currency. Participants noted that effective learning may be dependent on the instructor's ability to effectively engage and train students. Future research

could focus on identifying attributes that make an effective instructor that could then be used for instructor selection and training within the CF. CF members are often posted as instructors, and although they may be experts in their field, they are not necessarily good mentors. Participants argued that developing positive instructor attributes, by focusing on training instructors and by providing them with optimal support, resources, and networks may result in accelerated learning and benefit retention.

Timing of instructor training and application of training was also raised as an issue. Currently, instructor training is provided, however the lag between receiving training and actually teaching can be weeks, months, or even years. What impact (if any) this has on instructor ability is not well understood.

Participants also noted that instructor preferences may also influence the effectiveness of a training program. Some instructors may be better in a face-to-face classroom while others teach most effectively through online programs. A research possibility noted by participants involves investigating the context of instruction (class, distance, mentoring) with respect to the instructor's capabilities and preferences and the consequent effect of these issues on accelerated learning and retention.

Finally, CF instructors are posted to teaching positions, during which time they may not be kept current with operational activities (e.g., new /revised TTPs). Keeping instructors current in operational activities may assist in getting essential up-to-date information out to trainees. In addition, these efforts may assist in decreasing the time it takes to distribute essential information to troops being deployed. Research questions related to instructors are noted in Table 14.

*Table 14 Instructor attributes – Research questions*

| Research Topic | Research Questions |
|---|---|
| Instructor attributes | • What are effective instructor attributes and how can they be trained?<br>• How might the selection of instructors be influenced based on effective instructor attributes?<br>• Can the context or of instruction (class, distance, mentoring) be matched to instructor preferences and capabilities in order to accelerate training?<br>• How does operational currency (or lack thereof) influence the ability to effectively train students? Could improving operational currency be incorporated into a training program in a fashion that would accelerate learning and/or improve retention? |

#### 3.3.2.3 Delivery Media

Delivery media utilized in training has advanced with the technological boom. As was noted in all groups, the distinction between classroom aids, computer-based instruction, simulation-based instruction, and embedded training is ambiguous as these terms may all relate to similar technologies. Distance learning may also capitalize on such technologies. Thus, it may be beneficial to understand the ideas that came from discussion of these topics as a whole. Research questions that were identified from one topic may be relevant to another.

As a general comment, participants voiced concern that cost and technical knowledge may be an obstacle to implementation of different delivery media.

#### 3.3.2.3.1 Classroom Aids and Environment

Classroom aids and environment describe tools and different aids (e.g., concept maps, videos) that can be used within, and outside of, a classroom environment. The environment considers physical (e.g., noise, lighting) and psychological (e.g., learning culture) aspects of the learning environment that impact on trainees' ability to learn.

Participants noted that the use of classroom aids seems to be much more prominent in civilian society than within the CF. Two of the three groups noted that classroom aids have not been easily implemented into CF training for various reasons. The first is that there is a lack of strong evidence that classroom aids may be useful. Second, the CF may not have the resources necessary to acquire the aids. Lastly, there is a lack of knowledge and or resources to optimally implement classroom aids. Participants noted that there may be cases where the CF has the most updated classroom aids; however, they have not been evaluated to assess how they can best be used to achieve accelerated learning and increased retention.

One concern noted references the instructor's role. Classroom aids may require more effort from the instructor to be successful. This may not be feasible given that instructors often have additional responsibilities, tasks, and family life. The effective implementation of a classroom aid may also be highly dependent on the instructor's knowledge and teaching style. Consequently, using aids may mean that instructors may also require more training, which may or may not be feasible.

With respect to the classroom environment, one participant was particularly interested in the simple aspects of the learning environment such as ergonomics of the learning space (desk, chair orientation and comfort), field of view within the classroom, acoustics, and lighting. He pointed out that there are limited studies on the sensory aspects of the classroom. But this participant noted that these issues could significantly impact how trainees are able to interact with each other, with the instructor, and available equipment. Further research in this area, he argued, may result in accelerated learning. Questions that emerged from the discussion and participant comments are noted in Table 15.

*Table 15 Classroom aids and environment – Research questions*

| Research Topic | Research Questions |
|---|---|
| Classroom aids / Environment | What aids currently exist in civil society that effectively accelerate learning?<br>Can these aids be feasibly implemented within the current CF system and resources?<br>What makes classroom aids effective for accelerated learning?<br>Is it the ability of the instructor to effectively implement it?<br>Is it motivation of the student that is increased by its use?<br>Does the CF have classroom aids? If so, can they be evaluated, or implemented differently in order to achieve accelerated learning and improve retention. |

#### 3.3.2.3.2 Distance learning

Distance learning can be defined as learning that occurs outside of the traditional co-located classroom involving a separation of distance and/or time between the source of the information and learners.

Benefits and cautions related to distance learning were identified throughout discussions. Overall training time may be reduced with the implementation of distance learning due to reduced travel time and/or increased instructor time. Specific concerns about distance learning included student focus, performance standards, and the currency of distance learning research. These are each discussed in turn below.

Distance learning can reduce the time allocated to a course simply by eliminating travel time (e.g., one participant mentioned a course in Gagetown that was completed in 3 days through distance learning rather than the typical 5 day face-to-face course that includes travel).

Teasing apart whether certain distance learning sessions led to accelerated learning due to "distance learning" factors or "better instructional design" factors was also discussed. Some distance learning instructors have been noted to spend significantly more time creating their lessons while others do not. If no extra time is allotted, distance learning can become 'information dumping' that may not be effective. One group was specifically interested in separating out these success factors.

A caution noted about distance learning is that students are often expected to do distance learning in addition to regular activities. This takes away time and focus on that material that would be present in classroom sessions. Exactly how distance learning is implemented, then, may be vital.

An additional concern about distance learning expressed by participants was that performance standards can easily slip if evaluations are not effectively implemented. All aspects of the testing situation need to be considered in order to mitigate against learning violations (e.g., it may be easier for trainees to cheat) and ensure that material is effectively evaluated (e.g., simple multiple choice tests may not effectively test learned material).

Considering current research, a number of participants were concerned that studies and knowledge of distance learning may be significantly out-dated. Improvements in technology have changed the way generations acquire knowledge, and the speed at which this can be done. However, they argued that tools to best facilitate distance learning should be investigated. Questions that emerged from the discussion and participant comments are noted in Table 16.

*Table 16 Distance learning – Research questions*

| Research Topic | Research Questions |
|---|---|
| Distance Learning | How does one design a distance learning course with a superior instructional design that can accelerate learning?<br>If courses are developed with a superior instructional design, can they be successful at accelerating learning while having the additional benefit of eliminating travel time?<br>What is the best implementation of distance learning? |

| Research Topic | Research Questions |
|---|---|
| | What are the best tests for distance learning?<br>How are tests to validate distance learning best implemented?<br>Are there better ways to implement distance learning given new tools and technology? |

#### 3.3.2.3.3 Computer-based instruction

Computer-based instruction is increasingly used for delivering training. It has varying levels of complexity, ranging from low (e.g., typing tutor) to intelligent tutoring systems.

In each group, participants agreed that computer-based instruction overlapped with classroom aids, simulation-based learning, and distance learning. Participants were unclear about the relationships among many different forms of learning, for example, whether computer-based instruction encapsulated computer-assisted instruction (e.g., students at their own computer in a classroom with an instructor, intelligent tutors) and how it related to gaming environments. Both computer-based instruction software and gaming were discussed.

Participants recognized that computer-based instructional software increasingly involves not just one person and one program but multiple people and virtual spaces (e.g., web-based discussion board). Such asynchronous, distributed collaboration is a large benefit of using computer-based instruction. In addition, participants noted that computer-based instruction can be self-paced, however we do not know if this is beneficial or detrimental to learning and retention when this form of instruction would be maximally beneficial. There is similar concern with the timing of when asynchronous, distributed gaming simulations would be effectively implemented.

One participant suggested that research has not shown significant differences between face-to-face and computer-based learning, thus the benefit of implementing such systems should be investigated in the particular training program context.

A benefit of gaming environments was noted. Specifically, gaming environments can provide experiential learning that is motivating, and focuses on soft skills such as leadership (e.g., World of Warcraft requires good leadership and team effort in order to defeat the enemy). Questions that emerged from the discussion and participant comments are noted in Table 17.

*Table 17 Computer-based instruction – Research questions*

| Research Topic | Research Questions |
|---|---|
| Computer-based instruction | What computer-based instruction tools exist that may be beneficial to the CF?<br>In which cases is self-paced computer-based instruction beneficial?<br>In which cases is computer-based instruction that is systematically paced beneficial?<br>What skills can most effectively be trained through computer-based instruction?<br>Is there current research that demonstrates the benefit of computer-based instruction? |

#### 3.3.2.3.4 Simulation-based instruction

Simulator-based instruction is an increasingly prominent method of training delivery. The literature defines a simulation as a working representation of reality that shows devices and processes, and provides cues to elicit responses from the learner. A common distinction is between live simulation (real people using real systems), virtual simulation (real people in simulated systems) and constructive simulation (typically simulated people and simulated systems).

Discussions on simulation-based instruction touched on a number of different ideas; namely, benefits and concerns of simulation implementation, topics for which simulations could be applied, blurring of virtual and reality, acquisition of simulation equipment, and simulation-based curriculum development.

Participants agreed that the benefits of using simulations would typically outweigh any potential negatives. Simulations may be used in team tasks, team collaboration training as well as individual tasks. Participants noted that the infantry have used simulations which allow training to proceed as scheduled with no need to consider weather. Different terrains can be easily modeled to reflect the area of operations, and training can be repeated, recorded, and analyzed.

Participants also explored some concerns about the realism of simulation (e.g., removing the need to consider weather). The option to train under harsh conditions is not available in many of the currently used simulations. Similarly, there are both benefits and concerns about the potential for reducing training time through simulations. Physical and psychological fatigue that accumulates over long periods of real-time training would not be experienced with simulator training. Some of these aspects of realism that cannot be provided within simulators may be required for effective training.

Participants also noted that virtual and simulated space is increasingly becoming a part of real, daily life. The virtual world of on-line technology is increasingly becoming blurred with the real world through the use of distributed on-line tools such as Twitter and Facebook.

Additional concerns were raised that the up-front costs associated with simulation implementation may be high (e.g., financial costs, facilities and personnel resources). Simulations seem to be acquired and used only for a focused purpose. In future, it seems more effective to acquire simulation technology flexible enough to assist in a variety of training.

Specific topics that could be used leverage simulation-based instruction in the CF include language training and team leadership (i.e., learning not to micro-manage), particularly in the infantry. Participants argued that simulation-based instruction should emphasise soft skills (this was also mentioned in relation to computer-based instruction) rather than only the accumulation of technical skills or hard skills.

Finally, participants noted that simulation developers are not always knowledgeable about the types of learning, and learning objectives that takes place in each training program. Thus, developers may not realize the full potential of simulation implementation. Participants also noted

that perhaps contributions from trainers and trainees during the development of simulations and courses would result in more effective instruction.

Research questions that emerged from the discussion and participant comments are noted in Table 18.

*Table 18 Simulator-based instruction – Research questions*

| Research Topic | Research Questions |
|---|---|
| Simulation-based instruction | What type of simulation is best for what context?<br>What aspects of realism are lost in using simulation-based instruction? Are these essential in training? If so, how can their loss be mitigated?<br>Can simulations be used to effectively train soft skills?<br>How does virtual online 'realities' of simulations effect training, performance, learning, and retention?<br>Can simulation technology be more flexible / versatile in a variety of training?<br>Can training curricula be more effectively developed with designers and trainers are involved in multiple stages of the creation and implementation of simulation based instruction? |

#### 3.3.2.3.5 Embedded training

Embedded Training is defined as training that is built into or added to a weapon system (Witmer & Knerr, 1996). Another commonly used definition is provided by the U.S. Army Training and Doctrine Command, which defines embedded training as "A function hosted in hardware and/or software, integrated into the overall equipment configuration. Embedded Training supports training, assessment, and control of exercises on operational equipment, with auxiliary equipment and data sources, as necessary" (TRADOC Pamphlet 350-37).

As a general observation, participants commented on their lack of knowledge and experience with embedded training. With additional definition (based on the PowerPoint presentation) provided by HSI® researchers, participants seemed to agree there is potential for a lot of benefit to emerge from embedded training. The ability to switch into training mode during lulls in a mission (i.e. when there is relatively little action) would increase efficiency and perhaps increase performance and reduce additional re-training time. This type of switching between modes is seen in video games such as X-box and Wii. Embedded training may also make it easier to collect and utilize real operational data for training.

Though participants admittedly did not have extensive knowledge about what is involved in embedded training, it was suggested that embedded training seems only relevant to complex tasks rather than simple tasks.

Some concern was raised that there may be increased risk and cost associated with using equipment in training. Research questions that emerged from the discussion and participant comments are noted in Table 19.

*Table 19 Embedded training – Research questions*

| Research Topic | Research Questions |
|---|---|
| Embedded Training | How can embedded training be utilized within the CF?<br>How can embedded training be implemented effectively in the CF to achieve accelerated learning and/or increase retention? |

#### 3.3.2.4 Delivery Methods

Delivery methods discussed include a number of training methodologies and techniques that include collaborative learning, scheduling, feedback and testing, adaptive instruction, and context and content.

##### 3.3.2.4.1 Collaborative learning

Participants discussed the nature of collaboration in a team or group within the CF, information flow, and social aspects of collaboration that may affect learning. The use of technology to promote collaborative learning was discussed.

Teams within the CF are currently taught to perform as a team rather than learn as a team. Participants suggested that team training should target how to enhance the process of collaborative learning. Output from such training may result in trainees learning more when they conduct any team task (in training or performance).

Participants noted that collaborative learning provides opportunities that require trainees to participate in order to share expertise. As a benefit, all participants share in each other's expertise. On the other hand, as team training is currently implemented, even if collaboration is a focus, not all trainees get similar training experiences. For example, when demonstrations are used in training, trainees play certain roles and are only able to experience the task from that perspective. Timing and resources do not allow trainees to act in every role.

Collaborative learning may be affected if information flow within the system, or among team members, is hindered. Participants in one group were concerned that the general culture about information sharing is not always conducive to collaboration. The military, however, strives for a family-type culture in which sharing information between members is regarded as an important feature. It may be important to ensure that information sharing between echelons and branches (e.g., air, maritime, land) of the CF is facilitated.

Participants noted that there are several areas in which we know relatively little about collaborative learning. Notable gaps include the use of social networking and social media as they relate to CF training. The social aspect of collaborative learning as well as past training experiences (e.g., trained individually or as a group) are anticipated to promote learning. Research questions that emerged from the discussion and participant comments are noted in Table 20.

*Table 20 Collaborative learning – Research questions*

| Research Topic | Research Questions |
|---|---|
| Collaborative Learning | Should military teams be taught to learn together as a team rather than simply work together as a team? If so, how is this best accomplished?<br>How can collaborative and team learning be implemented to maximize training experiences for all trainees within the limitations of resources (e.g., time, equipment)?<br>Does information flow effectively throughout the CF in order to optimize training? How can this be improved? How can this be insured?<br>What are the social aspects of collaborative learning that may affect learning? How is it best to consider them to optimize learning and retention?<br>What type of technology (e.g., social networking, social media) plays a role in collaborative learning? How might it be leveraged for training? |

#### 3.3.2.4.2 Scheduling

Understanding how to schedule learning and practice may be an important way to promote accelerated learning and retention.

Participants discussed different perspectives of scheduling that may or may not be feasible. They also noted scheduling inefficiencies within the current system that affect learning and retention. Informal and formal training were discussed, as was the influence of technology.

Participants noted the difference between sequencing courses and scheduling a course. Sequencing relates to the order of courses, or of the material within a course, whereas scheduling a course relates to the timing of learning. Participants suggested that optimizing sequencing courses may improve retention. One way to do this is through a meta-examination of how best to sequence courses in order to optimize learning and retention. However, participants also expressed concerns that the sequencing of courses may require systematic changes within the training system that would be difficult to achieve.

Current scheduling inefficiencies within the system may negatively affect performance. For instance, current training is often provided at a particular time and not used until months or years later. The delay between learning and application may severely affect retention of material and consequently performance. Scheduling training appropriately so it is timely for application while reducing the skill retention interval, may benefit performance and help to reduce skill fading.

Participants also discussed current issues within the CF concerning scheduling issues around formal and informal mentoring. Mentoring programs and informal learning may be beneficial; however, formally scheduling these types of learning may detract from some of potential benefits. The nature of informal learning is not conducive to a natural progression of knowledge transfer.

Participants agreed that scheduling is an important topic that could be researched further to benefit accelerated learning and retention. With so many new methods of learning (e.g., distance learning, embedded training, simulation and computer based learning), there are many more

scheduling options that have likely not been thoroughly researched. Research questions that emerged from the discussion and participant comments are noted in Table 21.

*Table 21 Scheduling – Research questions*

| Research Topic | Research Questions |
|---|---|
| Scheduling | How does scheduling effect learning?<br>How can the sequencing of training programs be optimized to lead to accelerated learning and/or improved retention?<br>Are there inefficiencies within the current system that negatively impact on learning, retention and consequently performance?<br>Can scheduling be improved to reduce the delay between training and application of skills?<br>How can scheduling be optimized to accelerate learning given the extensive number of opportunities presented through technology? |

#### 3.3.2.4.3 Feedback and testing

Feedback can come from any number of sources (e.g., peers, instructors, computer systems) and with varying timing and frequency.

Participants discussed ideas about the use and type of feedback and testing, associated instructor responsibilities, and possible techniques. Participants argued that the idea that feedback and testing may be used as a source of learning and as a part of training may be an opportunity for further research. Possible questions include how such testing may affect retention, and how timing of testing and feedback may affect learning and retention. For instance, participants discussed their observations that, in some courses, an 'attend only' requirement may result in trainees taking the material less seriously and how incorporating testing may add a degree of 'seriousness' to course material.

Participants also discussed the idea that feedback may not always be beneficial. The struggle for trainees to understand their own mistakes may be required in order to recognize and overcome problematic behaviour. In addition, if feedback is provided the wrong way, it can be ineffective. For instance, delays in receiving feedback may cause the trainee to assume the worst about their performance and unnecessarily diminish their confidence.

Further, participants voiced their expectations that the type of feedback and testing would impact on learning and retention. The use of multiple choice tests was not thought to be the most effective method of assessing learned material, and participants argued that this method of testing may not maximize the learning experience. However, responsibility for developing and administering labour intensive feedback and testing (i.e., long answer questions versus multiple-choice questions) would fall on the instructor. Participants expressed concern, then, that this type of 'better' feedback and testing would negatively affect instructor's responsibilities, resources, and workload.

Research investigating effects of feedback and testing could focus on meta-cognition. Participants suggested that research should explore whether helping learners to observe their own

performance and provide their own feedback (e.g., self-correcting their mistakes) might help them to excel. Research questions that emerged from the discussion and participant comments are noted in Table 22.

*Table 22 Feedback and testing – Research questions*

| Research Topic | Research Questions |
|---|---|
| Feedback and Testing | How can feedback be implemented to optimize and accelerate learning and retention?<br>How can testing be implemented to optimize and accelerate learning and retention?<br>Can effective feedback and testing be developed and implemented with minimal resources allotted to the instructor?<br>How can meta-cognition be best applied to feedback and testing<br>How would strategies of how to provide their own feedback affect trainee learning and retention? |

#### 3.3.2.4.4 Adaptive instruction

Adaptive instruction can be defined as the deliberate tailoring of training and education to the needs of the individual.

Participants noted that emerging technologies play a large role in adaptive instruction. They understood adaptive instruction in terms of an instruction tool rather than as individual learning, which may be more in line with CF training goals. Concerns were raised that implementation of adaptive instruction may be limited by a number of factors.

Improvement and development of today's technology, such as the use of simulations, may increase the benefit of adaptive instruction in terms of promoting accelerated learning. Participants argued that although not previously feasible before the introduction of technology, adaptive instruction can be used within multi-player simulations. In these, there is no predetermined end-state and the 'game' is meant to evolve based on player activities in order to promote decision-making and team work skills.

For some participants, adaptive instruction was seen to be more relevant at the instructor level rather than for using technology to provide tailoring to individual needs. For instance, participants discussed adaptive instruction as a product evolved from AARs and lessons learned. That is, training is adapted based on lessons learned rather than on the difficulties of specific individuals. At the same time, however, participants recognized that this type of adaptive instruction may benefit skill decay. However, some participants argued that there may not be any prevalent evidence that such adaptive instruction actually works.

Concerns were raised that adaptive instruction may be hindered by large class sizes, scheduling, and instructor workload. Further research may focus on what technologies are available to assist in developing and implementing adaptive instruction within systemic limitations (e.g., resources,

class size, scheduling, timing, instructor resources). Participants were unsure about how and whether learning can be tailored to individual needs in order to promote accelerate learning.

Research questions that emerged from the discussion and participant comments are noted in Table 23

*Table 23 Adaptive instruction – Research questions*

| Research Topic | Research Questions |
|---|---|
| Adaptive Instruction | What new technologies are available for adaptive learning? Specifically in multi-player, collaborative simulations?<br>Would it be most beneficial to leverage adaptive training as a tool for instruction rather than specific to the individual?<br>What technologies are available to assist in developing and implementing adaptive instruction within systemic limitations (e.g., resources, class size, scheduling, timing, instructor resources)?<br>How do you adapt to the responses of the learner? Would that be helpful? |

#### 3.3.2.5 Context and content

The context and content category includes other features of the environment within which learning occurs, as well as specific contents of training (e.g., overlearning, whether cross-training occurs)

In general, participants discussed the difficulty of rating the category of context and content because the category contained multiple ideas. Participants noted that the context and content of training are essential in understanding learning and retention, though there was no further elaboration. Information flow, shift training, and levels of stress during training were noted during the discussion.

Information flow was noted by multiple groups and was a topic also discussed in collaborative learning. As a general observation, participants noted the CF requires a more flexible system that packages and relays lessons learned (e.g., new or changed techniques, tactics and procedures) to troops on the ground within reasonable time in order to increase operational effectiveness and success.

Participants discussed day versus night training and testing and how this may affect learning and retention. Day/night shift-training has been implemented in simulated environments, and is often seen as an efficient use of simulation. The effects on learning and retention however, have not been researched.

The level of stress that should be induced during training is another factor that can significantly impact training. Participants noted the extent to which stress should be implemented during training is not clear.

Research questions that emerged from the discussion and participant comments are noted in Table 24.

*Table 24 Context and content – Research questions*

| Research Topic | Research Questions |
|---|---|
| Context and Content | How can the CF streamline learning and circulate lessons learned more quickly?<br>How can the CF cut down on middle steps (data reporting, meetings) in order to hasten the circulation of lessons learned?<br>How does shift training affect learning and retention?<br>How can stress be used to accelerate learning and increase retention?<br>Is it productive or counterproductive to induce high levels of stress during training (e.g., as is done in MARS training)? |

#### 3.3.2.6 Retention

There were three separate topics related to retention discussed. These are expanded upon below.

##### 3.3.2.6.1 Retention – Relationship to learning factors

Retention is defined in the literature as the maintenance or sustainment of learned behaviours without practice or "the degree of competence to which an acquired skill [or knowledge] is retained through the passage of time" (Ginzburg & Dar-El, 2000, p. 327).

During the workshop discussion, topics identified under learning (student attributes, instructional learning, delivery media, delivery methods) were not explicitly discussed in relation to retention. Instead, the discussion concerning this topic focused on general ideas of research, level of training, and transfer of learned material.

There was some agreement among participants that research in this field may be out-dated, and/or not currently effectively applied. One participant suggested that the level of difficulty in training may reduce test scores and seemingly reduce level of learning, but perhaps retention is maintained or even increased.

The issue of transfer came up in the discussion connecting learning and retention. Participants argued that there may be training in which trainees perform well, but because conditions of the environment are so different when they get out into the field, little of the training is transferred. On a similar note, there may be a disconnect of transferring learned material if trainees are motivated during a training program but are not motivated to apply the learned material in the field.

Research questions that emerged from the discussion and participant comments are noted in Table 25

*Table 25 Relationship to learning factors – Research questions*

| Research Topic | Research Questions |
|---|---|
| Retention: Relationship | What areas of research in retention are out-dated? (this may consider effects |

| Research Topic | Research Questions |
|---|---|
| to Learning Factors | of new technologies)<br>How might the details of a training program (e.g., level of difficulty, scheduling, day vs. night training) affect retention?<br>What student attributes might affect retention (e.g., motivation)?<br>How learned knowledge is best transferred?<br>What factors might affect the transfer of learned material? How do these factors affect transfer of learned material as reflected in testing and performance? |

#### 3.3.2.6.2 Models of knowledge/skill retention

Discussion on models of knowledge and skill retention focused on the idea of refresher training, the type of models that may be useful to the CF, and the impact of technology.

In multiple groups, participants discussed that skill fading and refresher training is done seemingly based on arbitrary industry standards rather than on military-based research. General research in retention may also be very out-dated and may overlook today's standards and technologies.

In the CF, scheduling of resources seems to be the main factor that dictates when refresher training is implemented. Participants suggested that working to create models investigating when refresher training is required and how best it can be implemented given the systematic constraints of the CF would be an important research priority.

Multiple participants argued that developing a model of retention that is experiential will have more relevance to the CF than a mathematical model. It is expected that the number of variables included in such a model would be extensive. For example, the boundary of learning and retention could include all formal training, informal learning, and collaborative learning. An investigation and validation of existing models may prove useful in developing an approach to improve retention within the CF. Information development occurs much faster today than it has in the past. The speed of learning has completely changed and current models of knowledge and skill decay may be obsolete.

Research questions that emerged from the discussion and participant comments are noted in Table 26.

*Table 26 Models of knowledge/skill retention – Research questions*

| Research Topic | Research Questions |
|---|---|
| Models of Knowledge / Skill Retention | When is refresher training required?<br>How is refresher training best implemented given the systematic constraints of the CF?<br>What type of experiential model of retention may benefit training within the CF? |

#### 3.3.2.6.3 Techniques for retention

Participants noted that it may be useful to look to other industries for research on techniques for retention. The use of job aids were also discussed as a technique to increase retention resulting in increased performance.

There may be extensive literature within the corporate training/industrial world that could be useful to the CF. Options for further action may be simply to reconnect with the corporate/business world and understand techniques for retention from their perspective.

In order to effectively perform, it may be preferable to provide troops with job aids. Often, trainees do not have access to critical material after the course and do not have an opportunity to refresh their learning unless it is within the context of a structured course (e.g., refresher training). CF personnel may benefit from investigation of using job aids (e.g., a little book with key terms and information) which would refresh the material as needed. This may result in increased performance.

Research questions that emerged from the discussion and participant comments are noted in Table 27.

*Table 27 Techniques for retention – Research questions*

| Research Topic | Research Questions |
|---|---|
| Techniques for retention | How can literature from industry be leveraged to identify and implement techniques for retention within the CF?<br>Can job aids be implemented within the CF to assist in maintaining high retention rates and increase performance? |

### 3.3.3 Quantitative Results

#### 3.3.3.1 Ratings of Topics

During the workshop summary, preliminary analysis of the matrices data was undertaken by CDA facilitators. Based on the entries of participants (and participants' additive totals of the numbers), this analysis showed simulation-based instruction; instructor attributes, collaborative learning, and distance learning among the top four. Distance learning was ranked as the number 1 priority in this quick preliminary analysis.[1]

Upon presentation of these preliminary rankings during the after action review (AAR), however, participants expressed surprise that distance learning seemed to have emerged as the most important topic. One participant noted that their group had dismissed distance learning as an important topic because of the vast amount of associated research currently available. Others

[1] The rank discrepancy from the preliminary analysis was due to incorrect addition on the part of several participants. This error was corrected during the full analysis.

pointed out that distance learning can be considered a combination of a number of other issues (e.g., computer-based instruction, scheduling).

The fact that participants had expressed some surprise about distance learning being the most important research priority came into a clearer light with more detailed data analyses. With the time available to use the full data set provided by participants (rather than relying on their totals), it became clear that some of the preliminary calculations were incorrect. In actuality, more detailed analyses showed a somewhat different pattern.

Table 28 shows the mean importance ratings of each topic (and associated standard deviations) for each of the 13 participants.

*Table 28 Rating and rank of topics*

| Topic | N (sample size) | Mean | Standard Deviation | Rank |
|---|---|---|---|---|
| Simulator-based instruction | 13 | 3.99 | 0.42 | 1 |
| Instructor attributes | 13 | 3.8 | 0.59 | 2 |
| Collaborative learning | 13 | 3.8 | 0.55 | 3 |
| Distance learning | 13 | 3.74 | 0.48 | 4 |
| Computer-based Instruction | 13 | 3.74 | 0.69 | 5 |
| Techniques for retention | 13 | 3.7 | 0.62 | 6 |
| Feedback and testing | 13 | 3.69 | 0.37 | 7 |
| Embedded training | 13 | 3.69 | 0.57 | 8 |
| Context and content | 13 | 3.66 | 0.56 | 9 |
| Models of knowledge /skill retention | 13 | 3.65 | 0.65 | 10 |
| Student attributes | 13 | 3.59 | 0.85 | 11 |
| Adaptive instruction | 13 | 3.58 | 0.63 | 12 |
| Retention-Relationships to learning factors | 11 | 3.52 | 0.81 | 13 |
| Classroom aids/ environment | 13 | 3.45 | 0.42 | 14 |
| Scheduling | 12 | 3.22 | 0.73 | 15 |
| *Mean* | | *3.66* | *0.6* | |

Based on the mean importance rating they received, the 15 topics could then be empirically ranked in order of relative importance, treating all the criteria as equal. The top ranked topic is Simulator-based instruction with a mean of 3.99, followed by Instructor Attributes and Collaborative Learning tied in second place with a mean of 3.80. This was closely followed by Distance learning and Computer-based instruction (also tied) with a mean of 3.74.

The fact that the ratings of all topics are above the midpoint of the scale (i.e., 3) suggests that participants saw all of the topics as making a meaningful contribution to future research and

development efforts. Even the lowest rated topic (scheduling with the mean of 3.22) received a rating above the midpoint of the rating scale.

Given the low sample size, extensive analyses were not possible. However, given that the ratings were provided by all participants, it was possible to explore whether the means of the different topics (ranging from 3.99 for simulation-based instruction to 3.22 for scheduling) were actually statistically different. This analysis showed that the importance ratings for all 15 topics simultaneously did not differ significantly, although the highest and the lowest rated topics were significantly different.

Additional analyses were undertaken to explore the topics in relation to the 11 evaluation criteria. Given the pattern of results, it was important to understand why people believed simulator-based instruction was the highest priority. As shown in Annex E, simulation-based instruction was rated as having the highest level of scientific merit (m = 4.54), as being the most aligned with and supportive of the goals of the CF (4.38), and as being the most likely to attract industrial stakeholders (m = 4.62). Importantly, however, it was also rated as being in the mid-range of ease of implementation. This suggests that even those participants saw it to be highly important, they were less confident about the ability of the CF/DND to implement a wide range of simulation-based instruction.

#### 3.3.3.2 Ranking of Topics

The matrix spreadsheet included an additional column in which participants were expected to provide rankings of the relative importance of the topics based on a more holistic evaluation. This would offer a different perspective from the criteria ratings. Unfortunately, only one of the 3 break-out groups received specific instructions to complete these rankings and information about how to do this. This resulted in only four participants ranking all topics, and one participant ranked only their top three topics.

#### 3.3.3.3 Evaluation Criteria

It was also important to explore how participants rated the topics as a whole on the evaluation criteria. This would provide a broad perspective on whether the 15 topics identified during the literature review were actually seen to be important in the eyes of the workshop participants. Means and standard deviations for each criterion are shown in Table 29.

*Table 29 Means (standard deviations) of evaluation criteria*

| | N (sample size) | Mean | Standard Deviation |
|---|---|---|---|
| A – The topic has scientific merit. | 189 | 3.98 | 1.00 |
| B – The topic is novel or innovative in addressing learning | 190 | 3.48 | 1.18 |
| C – The topic aligns with and supports CF/DND goals. | 179 | 3.91 | 0.96 |
| D – The topic will have wide application within CF/DND. | 186 | 3.95 | 1.01 |
| E – The topic will improve organizational efficiency and/or | 181 | 3.88 | 0.91 |

| | | | |
|---|---|---|---|
| F – The topic will address identified gaps - learning and retention deficits - in the CF/DND. | 167 | 3.47 | 0.96 |
| G – The anticipated results of addressing the topic will accelerate learning and/or improve retention. | 185 | 3.72 | 0.96 |
| H – The anticipated results will be relatively easy to implement. | 178 | 2.80 | 1.11 |
| I – National or international collaboration on this topic is possible. | 171 | 3.85 | 1.06 |
| J – The topic will attract an industrial stakeholder for R&D. | 150 | 3.33 | 1.26 |
| K – There is sufficient capability and/or capacity within Canada to take on this topic for R&D. | 153 | 3.78 | 0.93 |

As this table shows, then, participants agreed that the 15 topics had a high level of scientific merit (mean = 3.98), that the results of emerging research would have wide application within CF/DND (mean = 3.95), and that they were aligned and congruent with CF/DND goals (mean = 3.91). Perhaps not surprisingly, the criterion with the lowest rating addressed how easy it would be to implement the findings of research. Given some of the break-out group discussions, this rating might reflect that even accumulating the best possible research and development may not address pervasive resource limitations of military systems. Ratings for all other evaluation criteria were above the midpoint of the scale, reflecting good agreement about the importance of future research within these topic areas, and good potential for meaningful contributions to the CF/DND.

### 3.3.4 After Action Review

As a conclusion to the workshop, participants were brought together to discuss their general thoughts on the topics, their ratings, and overall critique of the workshop. The final group discussion was intended to receive participant feedback about their completion of the matrix, and about their experience in the workshop.

**Topics** - After discussion during the break-out sessions, participants had completed the matrix rating each of the 15 topics on the evaluation criteria. One challenge noted by participants, however, was that some topics were multidimensional, but required a single rating. This meant that their rating of that topic would depend on how they constructed a single rating. A few participants noted that their ratings would change if they had the ability to narrow the topic to a specific idea. Although it is unclear how participants made this determination, it seems unlikely that they used the same strategy.

Several participants noted specifically that the Scheduling and Context and Content topics were too broad, consequently asterisks were marked for the majority (or all) of these criteria for these participants. Participants noted that even with the definition provided from the PowerPoint presentation, they felt the topics were too broad to accurately assess (Scheduling, Relationships to Learning Factors), or terminology was unclear (Embedded Training).

Participants suggested that criteria or topics that with high levels of non-response (i.e., not rated, but instead marked by at *) should be re-examined. For example, as described earlier, topics related to Scheduling and to the Relationship between learning factors and retention factors were

not well understood by some participants who used asterisks to rate all of the criteria for these topics.

**Evaluation Criteria** - In further discussion, participants noted that some criteria may be more important than others and heavier weighting should be given to those criteria. This would change the average ratings, and it would be interesting to then see how participant rankings compare.

Specifically, participants judged the last three criteria as being particularly difficult to judge.

I – National or international collaboration on this topic is possible;

J – The topic will attract an industrial stakeholder for R&D; and

K – There is sufficient capability and/or capacity within Canada to take on this topic for R&D

Based on this difficulty, they argued that these criteria should be given less weight when considering the results of participant ratings. Unfortunately, missing data does not allow for these analyses.

**General Discussion** - Participants voiced concern that although there may be clear benefits of implementing some changes to training in the long term, it may not be feasible within the structure of the CF. Hence, some suggested that the feasibility of implementation of research outcomes should be weighted significantly higher when considering future research and development.

Research areas will not be initiated if feasibility within the CF is low. Designating further research areas will require a balance between research needs identified, value, feasibility, and CF priorities.

A group discussion confirmed that participants felt the workshop was an interesting and effective way to elicit knowledge from stakeholders. Several suggestions relevant to future workshops also emerged. These included using mind maps to ensure common understanding about the meaning of the topic before break-out groups and/or allowing groups to create their own mind maps. This would ensure a clear idea of what the topic included.

Suggestions also included accessing the expertise of stakeholders in subsequent workshops through their ratings and rankings of more specific research questions. As noted earlier, some participants argued that the topics explored within this workshop were sometimes too broad.

## 3.4 Overview of workshop results

Participant discussions and their comments on the rating matrix provided a range of research questions about each of the 15 topics, as compiled in Table 30

*Table 30 Research questions gathered from discussion groups (in order of presentation)*

| Research Topic | Research Questions |
|---|---|

| Research Topic | Research Questions |
|---|---|
| Student attributes | • Can cultural differences be utilized to accelerate certain types of training?<br>• Does multitasking improve overall productivity for the new generation?<br>  ○ If informal learning takes place in multitasking environments, what are the effects on retention?<br>• What causes high motivation? Is it the student's intrinsic motivation, influence of the instructor, or classroom aids<br>• How does accounting for student attributes in practice schedules influence training effectiveness? |
| Instructor attributes | • What are effective instructor attributes and how can they be trained?<br>• How might the selection of instructors be influenced based on effective instructor attributes?<br>• Can the context or of instruction (class, distance, mentoring) be matched to instructor preferences and capabilities in order to accelerate training?<br>• How does operational currency (or lack thereof) influence the ability to effectively train students? Could improving operational currency be incorporated into a training program in a fashion that would accelerate learning and/or improve retention? |
| Classroom aids / Environment | What aids currently exist in civil society that effectively accelerate learning?<br>Can these aids be feasibly implemented within the current CF system and resources?<br>What makes classroom aids effective for accelerated learning?<br>Is it the ability of the instructor to effectively implement it?<br>Is it motivation of the student that is increased by its use?<br>Does the CF have classroom aids? If so, can they be evaluated, or implemented differently in order to achieve accelerated learning and improve retention. |
| Distance Learning | How does one design a distance learning course with a superior instructional design that can accelerate learning?<br>If courses are developed with a superior instructional design, can they be successful at accelerating learning while having the additional benefit of eliminating travel time?<br>What is the best implementation of distance learning?<br>What are the best tests for distance learning?<br>How are distance learning tests best implemented?<br>Are there better ways to implement distance learning given new tools and technology? |
| Computer-based instruction | What computer-based instruction tools exist that may be beneficial to the CF?<br>In which cases is self-paced computer-based instruction beneficial?<br>In which cases is computer-based instruction that is systematically paced beneficial?<br>What skills can most effectively be trained through computer-based instruction?<br>Is there current research that demonstrates the benefit of computer-based instruction? |
| Simulation-based instruction | What type of simulation is best for what context?<br>What aspects of realism are lost in using simulation-based instruction? Are these essential in training? If so, how can their loss be mitigated? |

| Research Topic | Research Questions |
|---|---|
| | Can simulations be used to effectively train soft skills?<br>How does virtual online 'realities' of simulations effect training, performance, learning, and retention?<br>Can simulation technology be more flexible / versatile in a variety of training?<br>Can training curricula be more effectively developed with designers and trainers are involved in multiple stages of the creation and implementation of simulation based instruction? |
| Embedded Training | How can embedded training be utilized within the CF?<br>How can embedded training be implemented effectively in the CF to achieve accelerated learning and/or increase retention? |
| Collaborative Learning | Should military teams be taught to learn together as a team rather than simply work together as a team? If so, how is this best accomplished?<br>How can collaborative and team learning be implemented to maximize training experiences for all trainees within the limitations of resources (e.g., time, equipment)?<br>Does information flow effectively throughout the CF in order to optimize training? How can this be improved? How can this be insured?<br>What are the social aspects of collaborative learning that may affect learning? How is it best to consider them to optimize learning and retention?<br>What type of technology (e.g., social networking, social media) plays a role in collaborative learning? How might it be leveraged for training? |
| Research Topic | Research Questions |
| Scheduling | How does scheduling effect learning?<br>How can the sequencing of training programs be optimized to lead to accelerated learning and/or improved retention?<br>Are there inefficiencies within the current system that negatively impact on learning, retention and consequently performance?<br>Can scheduling be improved to reduce the delay between training and application of skills?<br>How can scheduling be optimized to accelerate learning given the extensive number of opportunities presented through technology? |
| Feedback and Testing | How can feedback be implemented to optimize and accelerate learning and retention?<br>How can testing be implemented to optimize and accelerate learning and retention?<br>Can effective feedback and testing be developed and implemented with minimal resources allotted to the instructor?<br>How can meta-cognition be best applied to feedback and testing<br>How would strategies of how to provide their own feedback affect trainee learning and retention? |
| Adaptive Instruction | What new technologies are available for adaptive learning? Specifically in multi-player, collaborative simulations?<br>Would it be most beneficial to leverage adaptive training as a tool for instruction rather than specific to the individual?<br>What technologies are available to assist in developing and implementing adaptive instruction within systemic limitations (e.g., resources, class size, scheduling, timing, |

| Research Topic | Research Questions |
|---|---|
| | instructor resources)?<br>How do you adapt to the responses of the learner? Would that be helpful? |
| Context and Content | How can the CF streamline learning and circulate lessons learned more quickly?<br>How can the CF cut down on middle steps (data reporting, meetings) in order to hasten the circulation of lessons learned?<br>How does shift training affect learning and retention?<br>How can stress be used to accelerate learning and increase retention?<br>Is it productive or counterproductive to induce high levels of stress during training (e.g., as is done in MARS training)? |
| Retention: Relationship to Learning Factors | What areas of research in retention are out-dated? (this may consider effects of new technologies)<br>How might the details of a training program (e.g., level of difficulty, scheduling, day vs. night training) affect retention?<br>What student attributes might affect retention (e.g., motivation)?<br>How is learned knowledge best transferred?<br>What factors might affect the transfer of learned material? How do these factors affect transfer of learned material as reflected in testing and performance? |
| Models of Knowledge / Skill Retention | When is refresher training required?<br>How is refresher training best implemented given the systematic constraints of the CF?<br>What type of experiential model of retention may benefit training within the CF? |
| Techniques for retention | How can literature from industry be leveraged to identify and implement techniques for retention within the CF?<br>Can job aids be implemented within the CF to assist in maintaining high retention rates and increase performance? |

Fifteen concepts were presented at the workshop aimed at eliciting feedback from stakeholders. Group discussions were held on each of the topics and participants provided research questions, research ideas, comments, and completed ratings based on 11 criteria presented. Four participants also rank ordered the topics in addition to rating them.

Participant ratings of the importance of the 15 topics showed that Simulator-based instruction was rated as the highest priority with a mean of 3.99, followed by Instructor Attributes and Collaborative Learning tied in second place with a mean of 3.80. This was closely followed by Distance learning and Computer-based instruction (also tied) with a mean of 3.74. All topics were rated as making a meaningful contribution to future research and development efforts as average ratings were all above the midpoint of the scale.

The discussion in the AAR was generally consistent with the overall empirical rankings. That is, the use of technology was a reoccurring theme throughout the majority of discussions. There was also concern of the feasibility of implementing change within the current structure CF because resources are often strained. Overall, the participants felt that the workshop was a productive activity and follow-on work also involving stakeholders would be beneficial to the research program.

As a whole, then, the goals of workshop were met. The information provided by participants offers an important perspective on the needs of the CF/DND system as it works to conduct research and development to improve its training and education system.

# 4 Conclusions

The purpose of this work was to identify the most promising topics for Research and Development (R&D) on Accelerating Learning and maximizing knowledge/skill retention that could yield greatest benefit to the Canadian Forces (CF) within five (5) years. This scoping study consisted of a review of relevant literature and a workshop. The literature review provided a broad overview of current knowledge in the scientific, military, and related literature relevant to accelerated learning and retention. It was noted that the factors that influence skill acquisition are not necessarily the same ones that influence skill retention. The literature review showed that the construct of accelerated learning is still at a relatively early stage of development and that much research is required to fully understand accelerated learning and retention in a CF context.

As noted in the previous section, the primary outcome of the workshop was the rating of the primary topics of interest. Not surprisingly, simulator-based instruction received the highest importance rating from participants, and was seen to have a high level of scientific merit as well as being the most aligned with and supportive of the goals of the CF, and as being the most likely to attract industrial stakeholders. Given the strong push to use simulation for training within both civilian and military contexts, this result is perhaps unsurprising. Given the high ratings for distance learning and computer-based learning, there is clear agreement about the potential role that technology needs to play in helping to promote accelerated learning. Knowing more about how technology can be used to promote higher levels of learning and retention will be critical as future efforts unfold.

Even among all the new technologies that could be used to promote learning, however, it is important to note that attributes of the human instructor received the second highest rating from workshop participants. They noted the importance of research exploring the match between instructor's capabilities and preferences, and the new technologies used for instruction such as distance education. What makes an instructor capable of being effective even when interacting remotely with a student seems an especially interesting question given the introduction of new learning modalities.

Given the nature of many military tasks, collaborative learning is another topic emerging from this project that should receive research attention. Understanding how team members can best learn what they need to learn as a team is critical to ensure the highest level of effectiveness. What role technology could play in facilitating that team effectiveness should also be explored. Specifically, there is interest in determining if popular collaborative technology (e.g., social networking, social media) could be effectively used in CF training.

One important finding emerging from both the literature review and from workshop discussions is that there is no single topic that will help to "take the brakes off" of learning and promote high levels of retention. Indeed, the many different influences on learning include the student, the

instructor, how training material is presented, and whether it occurs collaboratively or individually. Nonetheless, as the literature review shows, although there is a complex matrix of influences to navigate, there is also considerable potential for making contributions to the literature through future research and development efforts.

# 5 Future Research

Focusing on the top six ranked concepts arising from the workshop and review (i.e., simulator-based instruction, instructor attributes, collaborative learning, distance learning, computer-based instruction, and techniques for retention), a number of specific future research options are explored below. Specific research programs could focus on the following issues:

- One potential means of encouraging collaborative learning is through the use of social networking tools (e.g., Facebook, Twitter, Blackboard, etc.). Specifically, research could explore the role that these tools might have in facilitating accelerated learning in the CF. This research could document current social networking tool usage within the CF (if any) and best practices. This work could also explore potential uses and benefits that these tools might offer. This could be facilitated by exploring how these tools are used in other educational (or broader) contexts. This research could include both a focus on how the tools could be used by instructors (e.g., using a Wiki page to collect information related to challenging topic areas) as well as how the tools could be used by students (e.g., communicating over instant messenger or Twitter for project collaboration).
- The role of changing demographics (i.e., aging population, generational differences) on education and training in the CF is another future research area. Research could begin by documenting and understanding generational differences (e.g., acceptance of technologies, effects of multitasking on productivity) and the impact of these differences on learning and retention. Experimentation could also be conducted exploring the roles that these factors play in accelerated learning for different demographics, perhaps suggesting best practices based on learner attributes.
- More of a research focus could also be placed on trainers in order to develop train-the-trainers programs that can lead to accelerated learning. This program could update trainers on what other trainers are doing, suggest broader training options and in general seek to ensure that trainers are up-to-date on established best practises in education and training. These train-the-trainer programs could be developed for specific trainers deemed most in need, or more generally created to apply to all educators and trainers in the CF.
- As discussed in earlier sections of this report, the full list of 15 potential research concepts were all rated above the mean, indicating they were all seen as relevant concepts for further research (see Table 28). Although this is encouraging, there is little information in these ratings that helps to truly distinguish the most critical CF needs. With that in mind, it may be beneficial to further refine the current rankings with a broader set of expertise. One means of refinement could be through interviews at various educational and training facilities across the CF. By talking with current students and trainers about their concerns and issues, a fuller understanding of the major impediments to accelerated learning could be reached. Analysis of these interviews could further inform research and development efforts seeking to benefit training within the CF to help promote acceleration of learning and improved retention.

Whatever the future approach, there are many critical questions related to accelerated learning and retention that are remaining to be answered through future research and development efforts.

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# Annex A Workshop Introductions

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## A Project on Accelerated Learning and Skill / Knowledge Retention

**Why:**

- Personnel shortage
- Potential generational mismatch
- Increasing job complexity
- Stressors
- Training policy and process
- Science and Technology pull



## What's the Science?

The Science of this project is study of

- human learning
- training transfer, and
- knowledge and skill retention
- expertise and the transition of novice to expert
- human information processing, human memory and decision making,
- all the factors that impact on these abilities.

## Overlap between Human and Machine Performance

- Learning, training transfer, and retention are not exclusive to human performance
- Maybe the best way of solving these problems will be a merging of human and machine capabilities



## Possible way-ahead

- A phased work plan
  - Phase 1 - a scoping study and workshop that will
    - identify the factors that impact most upon the acquisition and retention of knowledge and skill, and
    - identify the areas for R&D that will have most impact potential by considering the technology gaps, national S&T capabilities, and collaborative opportunities
  - Phase 2 - a project plan that consists of
    - a number of work elements that address the target areas
    - contract for prosecution of the work
    - partnerships and collaborative arrangements for leverage of the investments
- A DRDC / CDA work team
  - engaging TTCP countries, through HUM TP2 (Training Technology) and to leverage the NATO RTO
  - follow-on NATO Exploratory Team (ET) and Research Task Group (RTG) to HFM 121/RTG165
  - ADL network – in Canada and internationally

# Workshop Schedule / Process

| Time | Event |
|---|---|
| 0800 | Introduction<br>LCdr Peter Ball (Learning Concepts, CDA HQ, Kingston ON) |
| 0815 | Presentation<br>Dr Dee Andrews – (Senior Scientist, Human Effectiveness Directorate, USAF Research Lab, Mesa, AZ ) |
| 0845 | Presentation<br>Dr Robert Hoffman – (Senior Research Scientist, Florida Institute for Human and Machine Cognition, Pensacola, FL) |
| 0915 | Topics<br>Dr. Barbara Adams (Senior Human Factors Consultant, HSI Inc, Guelph ON) |
| 1030 | Refreshment Break |
| 1045 | Criteria<br>Dr Lochlan Magee (Defence Scientist, DRDC Toronto ON) |
| 1115 | Dry run<br>Capt John Wyville (TESM Standards, CDA Headquarters, Kingston ON) |
| 1200 | Lunch Break |
| 1300 | Break-out Group Activity |
| 1530 | Workshop Summary |

## Annex B Guest speaker presentation: Dr. Dee Andrews

# Accelerated Learning and Long Term Retention of Expertise

Feb 2011

**Dr. Dee Andrews**
Senior Scientist
Human Effectiveness Directorate
Air Force Research Laboratory

## Tasking & Definition

**-- DSTAG Tasking --**

**"The Human Systems team should baseline the existing programs (understand current/planned investments including cognitive techniques) and identify new ideas/technologies to be pursued."**

**What is "accelerated learning" ?**

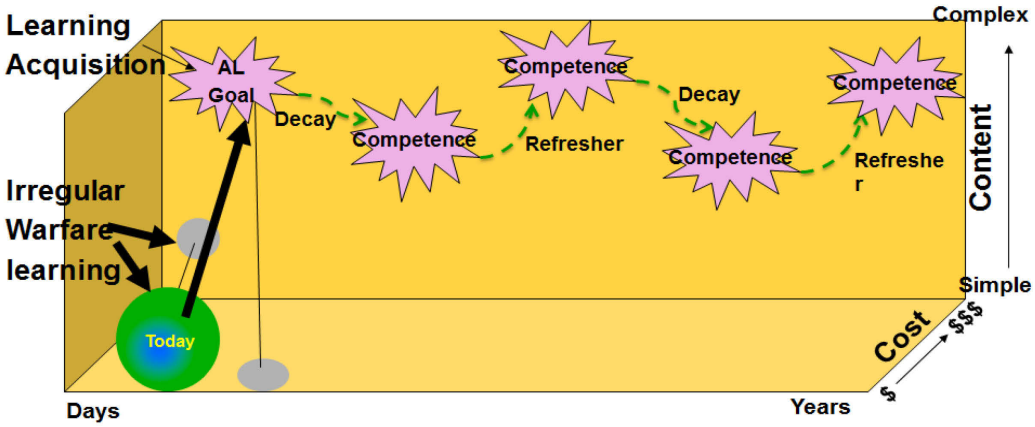
**-- The TFT's Definition --**

**Any learning system or environment that attempts to control for *time* spent versus *content learned* with the following goals:**

- **Faster attainment of skill and knowledge then a current baseline, and increase in on the job performance with better retention of learning**
- **Quickly assimilate and convert to training content battlefield lessons learned**

2

# AL = Optimize Options in a Learning Acquisition TRADESPACE




3

# The Accelerated Learning Challenge

Current Warfighters are required to perform tasks for which they may not be well trained, when time is of the essence.

**Examples of difficult tasks that must be quickly mastered in:**

**Irregular Warfare (IW),**

**Counterinsurgency (COIN), and**

**Stability, Security, Transition, Reconstruction Operations (SSTRO)**

- **Real-time situational understanding**
  - **Determine the military implications of fused intelligence indicators, all source information, orders of battle in the context of Diplomatic, Informational, Military, and/or Economic (DIME) / Political, Military, Economic, Social, Infrastructure and Information Systems (PMESII)**
    - **Develop options in Air Operations Centers in context of "whole-of-government" engagement**

4

## The Accelerated Learning Challenge

**Examples of difficult tasks (continued)**

- Dynamic planning/replanning
  - Kinetic battlespace skills
    - ➢ Maritime battlespace management and the prevention of mutual interference in coalition ops
  - Non-kinetic knowledge development and analytic skills
    - ➢ In real-time Brigade ops planning -- evaluate, assimilate, and act in both the physical and civil (political, cultural, and economic) environments of the battle space leveraging non-military organizations
- Interpersonal skills (the cultural chameleon)
  - Achieving and making use of societal and cultural awareness

5

## Key AL S&T Challenges that are Minimally or Not Funded

- Understanding the requirements for proficiency and how to accelerate its attainment
- Understanding how to increase retention of competence – "accelerated retention"
- Making practical serious games for use in AL
- Developing technology for rapid understanding of learning problem e.g., rapid cognitive task analysis
- Determining level of competence required for different stages of a war fighter's career
- Calculating the cost-benefit of implementing AL

6

## Accelerated Learning Principles

**Routine practice is not sufficient for acceleration of competence. There needs to be:**

- A constant "stretching" of the skill, defined by increasing challenges (tough or rare cases)
- High levels of intrinsic motivation to work on hard problems
- Practice that provides rich, meaningful feedback
- Practice based on mentoring
- Provisions for individualized/tailored practice due to unique learning styles of each learner

7

## Example Accelerated Learning Techniques from Cognitive Science

- Optimal spacing of materials
  - Spaced is better than massed practice (Kornell & Bjork, 2008; Dempster, 1989; Melton, 1970; Rohrer & Taylor, 2006)
  - Optimal spacing: present enough repetitions so that material is mastered, but overtraining is an inefficient use of time
  - Optimal spacing depends on how long material should be retained for – optimal ISI interval = 10-20% RI interval (Rohrer & Pashler, 2007)
- Using tests to improve learning, not just assessment
  - Advantage of study-test over study-study (McDaniel, Roediger, & McDermott, 2007)
  - The importance of active retrieval for learning (Karpicke & Roediger, 2008)
- The benefits of self-explanation (Chi, 1996, 2000)
- Directed comparison for revealing deep principles (Gentner & Namy, 2004; Loewenstein, Thompson, & Gentner, 1999; Rittle-Johnson & Star, 2007)

8

## AL methods for IW/COIN/SSTRO Readiness Training and for Mid-Career Competence Learning

### Sample Training Guidelines for Developing Proficiency

| | |
|---|---|
| **Competent performers know a lot.**<br>**Their knowledge is highly contextual.** | Training must provide increasingly detailed knowledge, procedures, principles, in context, with progressive refinement as expertise develops. |
| **Competent performers' knowledge is structured.** | Provide suitable knowledge structures early in training. |
| **Competent performers knowledge / skill is compiled and proceduralized** | Provide sufficient practice for experience to be compiled. |
| **Competent performers can work forward from underlying principles or backwards from the end goal. It depends upon the case.** | Provide underlying principles as part of the knowledge structures. Provide unstructured end-goal exercises only after principles have been learned. |
| **Competent performers can examine a broad range of alternatives or explore a single alternative deeply.** | Practice environment must provide for many alternatives and must model them correctly. |
| **Competence keeps developing even after many years and thousands of opportunities for deliberate practice.** | Provide journeyman-expert practice environments through simulation and carefully designed exercises. |

9

## -- an Example of Accelerating Competence -- Adaptive Thinking Training "Think Like a Commander"

Thinking that supports:

making adjustments in an unfolding plan under the dynamic conditions of military operations.

**Specific Training Task**

**The ability to rapidly and accurately 'size up' tactical situations: identify important considerations, risks, key information, alternative actions, potential higher-order effects, and other factors that may be significant in decision making during execution.**

**J. Lussier, 2008**

10

## First Generation in AL
## -- an Example of Accelerating Competence --

***Adaptive Thinking: A key battlefield thinking skill—making adjustments in an unfolding plan under dynamic conditions of military operations.***

### Activities Specifically Designed to Improve Performance

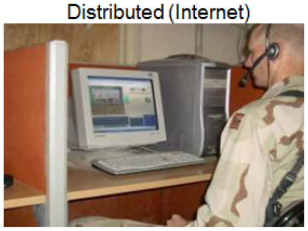
- Identify desired elements for expert form
- Learner performs while attending to element
- Coach notes discrepancies from expert form
- Behavior is repeated until habitual
- Performance without attending to expert form

### ***Expert Cognitive Behaviors***

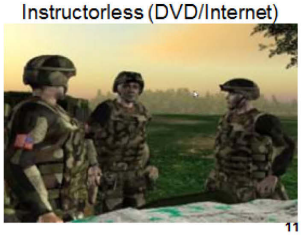
- Keep a focus on the mission and higher intent
- Model a thinking enemy
- Consider effects of terrain
- Use all assets available
- Consider timing
- See the big picture
- Visualize the battlefield
- Consider contingencies and remain flexible

Classroom

Distributed (Internet)



Instructorless (DVD/Internet)



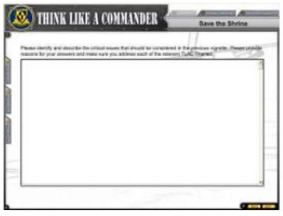
11

## Captains in Command

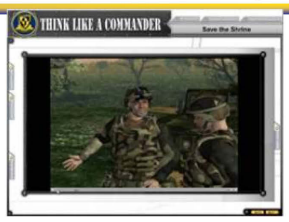
**1. Students receive training on the expert Themes of Battlefield Thinking and observe model behavior.**

**2. Students view a 3-5 minute theme-based vignette that presents a complex and rapidly changing tactical situations.**

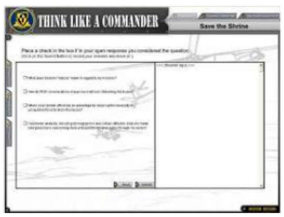
**3. Students are asked to apply their tactical knowledge to think adaptively and list their key considerations.**




**4. Students view a 3D coach or live instructor discussing expert considerations pertaining to each of the battlefield thinking skills.**




**5. The students are prompted to evaluate their response based on expert considerations and respond to coach's questions.**




**6. After covering each of the eight themes, students are provided feedback to his or her responses.**

12

## Characteristics of Incredibly complex Tasks ( ICTs )

| | |
|---|---|
| Abstract | Physical phenomena or causation are not readily visible |
| Multi-variate | Many variables underlie outcomes. |
| Interactive | Changes in one variable may affect several others. Processes are co-dependent. |
| Continuous | Physical phenomena and their effects are described as values along continua, rather than as discrete properties. |
| Non-Linear | Relations among variables are not simple straight-line functions |
| Dynamic | The process of variation is of interest, rather than end-state |
| Simultaneous | Systemic variation is coincident rather than serial. |
| Conditional | Outcomes are highly dependent on boundary conditions and context. |
| Uncertain | Exact values of underlying variables are not known precisely – they may be estimates, interpolations, approximations |
| Ambiguous | The same outcome may arise from different combinations of inputs. |

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## Implications: Instructional Design for Incredibly complex Tasks

| | |
|---|---|
| Abstract | Develop visualizations that explain physical phenomena and causation |
| Multi-variate | Develop simulation-based/physics-based problem space in which effects of variation can be explored |
| Continuous | Do NOT use discrete or static cases for training. Provide practice for continuous variation. |
| Non-Linear | Explore the non-linearity: provide practice that concentrates on inflection points, minima, maxima, zero-crossings, asymptotes |
| Dynamic | Practice environment must include dynamic complexity – Scenarios must present continuous evolution. |
| Interactive | For high-way interactions, systematically hold some variables constant while exploring variation. Use no more than three-way interactions for problem cases. |
| Simultaneous | Develop mental model for simultaneity as underlying interaction, not serial causation. |
| Conditional | Provide highly contextualized practice environment which is capable of supporting practice in high-difficulty real-world warfare environments. |
| Uncertainty & Ambiguity | Teach methods / procedures for resolving uncertainty / ambiguity. Practice environment must properly replicate these effects. Develop test scenarios which exploit uncertainty. |

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## Paradoxes

- Accelerating learning *may* have negative effects on retention of what was learned. The sweet spot must be found
- Accelerating learning in one area *may* have negative consequences in terms of generalizability to a different situation
- Shorter/faster training *may* result in a lack of readiness for task performance

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## Conclusions

- Additional methods of accelerating the attainment of competence are required, with a particular focus on military domains
- To gain a greater understanding and improve training during these periods, longitudinal and long-term retention studies are needed
- Policy issue is harder than methodological issues
  - Difficult to obtain funding for a long-term (10-year) program
  - Project A was an exception
    - Long-term cross service program to collect personnel data
    - Faced with period threats of budget cuts

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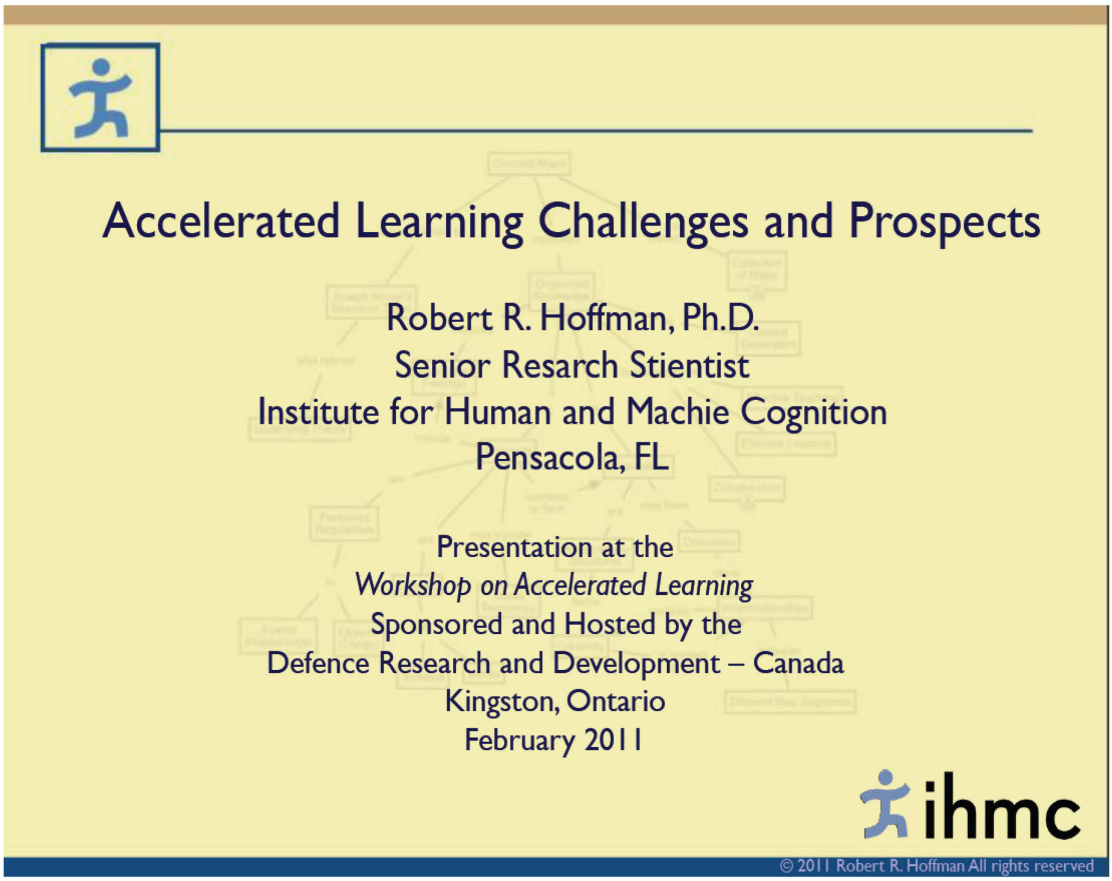
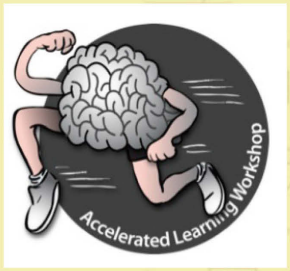
# Annex C Keynote address: Dr. Robert Hoffman






711 Human Performance Wing U.S. Air Force Resaearch Lab

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## The Problem

65%+ of senior engineers in electric utilities are eligible for retirement. How to escape the "ten-year rule"?

Fighter pilots return from desk jobs. Their skills have eroded and the job itself has changed. How to rapidize their re-achievement of expertise?

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## NEED

Domain practitioners who achieve high levels of proficiency provide technical judgment to speed decision-making in time-critical events.

They provide resilience to operations by resolving tough problems, acting prudently by judgment rather than by rule, and anticipating future demands with re-planning.

They exercise effective technical leadership in ambiguous or complex situations.

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## CHALLENGE

It typically takes years of experience for professionals to master their domain.

Reasons for this include domain complexity and the need for extended and continuing practice at rare and difficult cases.

The challenge of achieving and maintaining high proficiency is compounded in the military by such practices as collateral assignment, redeployment (e.g., rapid skill decay on the part of pilots creates a need for expensive re-training), inadequate or ad hoc mentoring, and the drive for "just-in-time" training.

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## Meanings of Accelerated Learning

Rapidized Training

How to quicken the training process while maintaining effectiveness

Rapidized Knowledge Sharing

How to rapidize the transposition of lessons learned from the battlespace into the training context

Accelerated Proficiency

How to train more quickly to higher levels of proficiency

Facilitated Retention

How to insure that training has a stable and lasting effect

Rapidized Cognitive Task Analysis

How to rapidize the process of creating training materials from expert knowledge

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## DOMAINS

Cultural understanding
PIMESII
Fused sensing and layered intelligence
Influence and information operations
Second language learning
Power generation and coordination
Weather forecasting,
Software engineering,
STEM fields, cybersecurity
Cultural awareness
Personnel management
General command
Piloting (fighters, UAVs)

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What might work?

What would you need to know about the domain?

Concerns and anti-goals?

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## Success Stories?

- Intelligent tutoring systems
- Simulation-based training
- Top Gun
- National Training Center
- Think Like a Commander
- WRTI's OpSim™

Others?

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## REVIEW RESULTS: Training

Training at advanced levels (training to perform in dynamic and complex domains where tasks are not fixed) is generally more effective if it involves extensive practice on realistic examples or scenarios (e.g., problem-based learning).

Training has to balance giving and withholding of outcome and process feedback to achieve optimal learning at different stages of advancement.

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## REVIEW RESULTS: Training

Training at intermediate and advanced levels benefits significantly from experience at challenging problems or cases, the "desirable difficulties." Short-term performance might suffer, but longer-term gains will emerge.

Mentoring is valuable and critical for advanced learning, because it provides opportunities to receive rich process and outcome feedback as learners encounter increasingly complex problems. However, mentoring is not always necessary in advanced stages of learning.

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## REVIEW RESULTS: Transfer

Initial learning that is more difficult can lead to greater flexibility and transfer.

Transferring a skill to new situations is often difficult but can be promoted by following a number of training principles.

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## REVIEW RESULTS: Retention and Decay

There is a beneficial effect of spacing on learning and memory when the goal is long retention intervals.

Retention is better if the same task is never practiced on successive trials, but is randomized with other practices.

Significant decay can occur even within relatively short time frames (days to weeks) for any form of skill or learned material, including that involved in military tasks.

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## REVIEW RESULTS: Retention and Decay

The best predictor of skill retention following a hiatus is the level of performance achieved (including over-learning) prior to the hiatus.

The variable having the largest impact on performance after a retention interval is the similarity of the conditions of testing to those of the training.

Overlearning is the prime determinant of memory and skill decay: The greater the degree of overlearning the less decay and the less rapid the decline.

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## REVIEW RESULTS: Teams

Team training must consider content knowledge, perceptual-motor skills, reasoning skills and strategies (of course), but also coordination and collaboration skills, and attitudes appropriate for teamwork.

Communication is key to process and performance. High performing teams effectively exchange information in a consensually agreed-upon manner and with consistent and meaningful terminology, and are careful to clarify or acknowledge the receipt of information.

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## REVIEW RESULTS

None of the above generalizations holds uniformly; for all of the above, one can find studies showing opposite effects, or no effects.

Learning, training and instructional design are highly complex, with multiple interacting factors, makes it impossible to compose a recipe for instructional design for proficiency training.

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## REVIEW RESULTS

In an ideal situation, one would be able to trace the effects of instruction, from the very beginning, noting its effect across the entire span of learning various knowledge and skills, right through to final operations performance.

Reasons why this is not possible.....

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## INDETERMINATE CAUSATION

The time taken for the changes due to training to percolate through to operational effects can be long, and involves complex interactions with other functional realities, such as organizational constraints and operational pressures.

There is no straightforward track, from the formal process of lessons-learned to eventual operational performance, that would enable us to give credit to any particular training factor.

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## INDETERMINATE CAUSATION

Operational outcomes are so contextually and circumstantially driven that they defy backwards-looking interpretation necessary to understand cause-and-effect linkages.

Operational effectiveness outcomes are tied to scenarios and circumstances, making it impossible to get representative coverage permitting generalizations that specify which training inputs are effective in meeting which possible or future operational challenges.

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## THE PARADOX OF JOBS

As technology changes, as assignments change, and as jobs change, the cognitive work changes.

Learning and re-learning on the job must be continuous. But there is too much to train, in too little time. Thus, the pressure is to do Just-in-Time training, but such training is at odds with notions of proficiency training.

The practice of rotating the most highly-trained and experienced pilots to other duties and responsibilities and then sometimes rotating them back into piloting or pilot training.

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## THE PARADOX of TASKS

Traditionally, training depends on componential analysis of relatively stable tasks that can be described as series of steps or procedures.

But cognitive work is the context-sensitive, knowledge-driven choice among alternative activities.

The traditional concept of "task" may actually be an impediment to advances in research and theory in that it reinforces an artificial notion of separability.

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## PARADOXES of CAREERS

Paradox of Domain Specificity
The Envisioned World Paradox
The Moving Target Paradox
Paradox of Feedback
The Skills-Capacities Paradox
Paradox of Tough Tasks
The Paradox of Failure
The Irony of Evaluation

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## Summary

Can learning be accelerated (how much)?

For fixed tasks, yes.
For dynamic tasks, likely

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## Summary

Does acceleration of learning penalize retention?

We do not know.
Question is not does it penalize, but how does it impact?

How does acceleration of learning retention following hiatus?

We do not know.

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## Research Needs: Methodology

Research must establish methods for rapidized cognitive task analysis.

The most frequently mentioned training challenge was the pace of change in domains of professions practice, including in military jobs and specialties.

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## Research Needs: Methodology

What makes for a good mentor?

How to identify individuals who could become good mentors?

How to teach people how to be mentors?

What are the most efficient and appropriate ways of using mentoring to achieve accelerated learning?

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## Research Needs: Methodology

Expand our empirical base about how periodic booster sessions (number, spacing) might affect forgetting rates.

Expandour empirical base about differential decay of particular abilities.

Booster training should focus on refresh of skills that would ordinarily show faster drop-off.

Procedures for rapidized updating both during and post-hiatus, because during a hiatus, the missions and the technology are constantly changing.

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## Acceleration Methods

Computer games, simulations, and immersions, all of which are enhanced through application of intelligent tutoring and artificial intelligence capabilities.

Case-based instruction and realistic tough cases with focus on errors and "desirable difficulties."

Meaningful corrective feedback that is appropriately timed (neither too close nor too distance from the performance being evaluated).

Tough-case time compression

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## Summary Roadmap

Where should R&D (in behavioural sciences or technology) be expended to best effect?

- ✓ ≥ 2 pilot projects, interestingly different domains
- ✓ Longitudinal (cohort-select)
- ✓ Domans with civilian analogs
- ✓ Domains with recently transformed strategic environment, where people have more than one duty assignment
- ✓ Dynamic tasks and challenges (versus "tasks")
- ✓ Intyegrated knowledge management component

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## Summary Roadmap

Prospective and retrospective studies.

The paramount goals of a research program would be:

(1) Facilitating the achievement of proficiency, *especially in the Apprentice to Senior Journeyman levels,*

(2) Retaining expertise in the form of both personnel capabilities and in the form of organizational knowledge,

(3) Applications to military domains including mission-critical specializations.

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## *Thank you!*

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# Annex D Presentation of topics

## Accelerated Learning and Retention Workshop – 11 Feb 2011

**Dr. Lochlan Magee – DRDC Toronto**

**LCdr Peter Ball, Lt(N) Calixte Wondje and Capt. Gregory Jones – CDA**

**Lisa Rehak, Cheryl Karthaus and Barb Adams – Humansystems**

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## Goal

- Quick overview of literature review
- Identification of emergent topics
- Definition, description of each topic
- Examples of questions that might emerge

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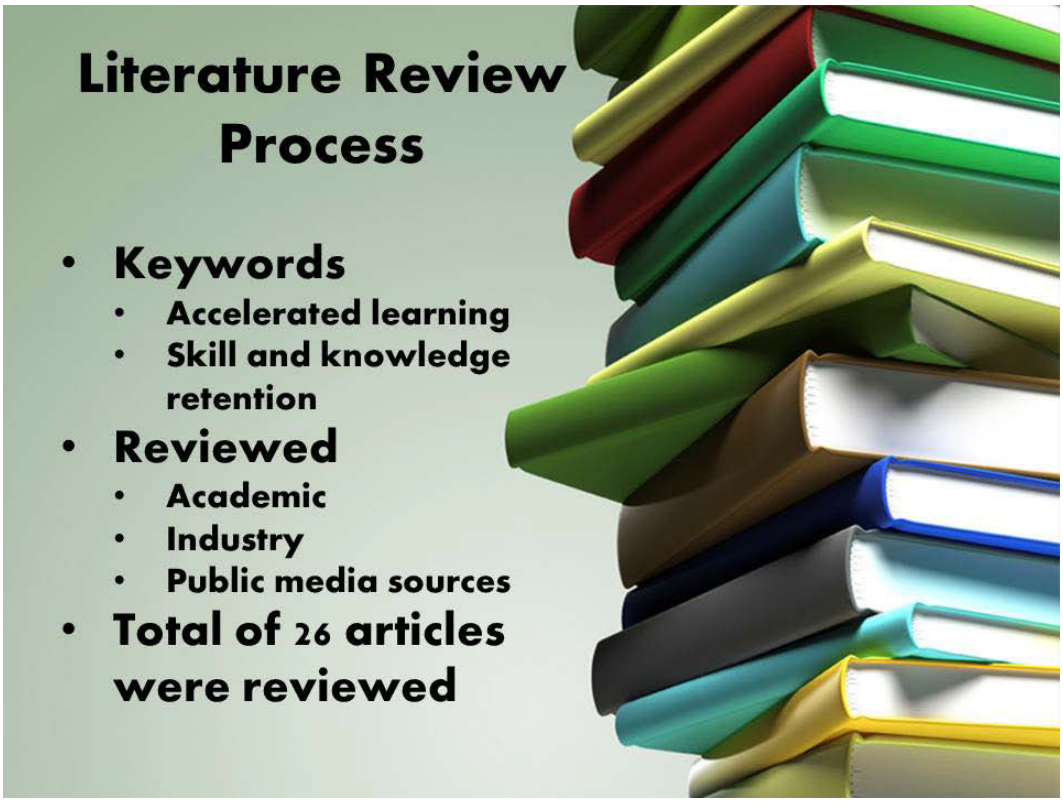

## Findings of the Scan

- Identified a wide range of factors that affect learning and retention of knowledge and skills
- Many gaps in relevant literature
- Narrowed to 15 key topics related to learning (12) and retention (3)

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## Two Theme Categories

## Learning Theme Categories

## Learning Theme Categories

# Learning Theme Categories

## 1) Student attributes

- Students naturally vary in their learning potential and style
- Prominent dimensions are cognitive ability, motivation, learning styles, prior experience (e.g., training and education)

## Student Attributes: Example Questions

- What student attributes are most critical to learning?
- How can training be designed to maximize student motivation?
- Should we further investigate the importance of learning style preference?

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## Learning Theme Categories

## 2) Instructor Attributes

- Level of subject matter expertise
- Teaching experience
- Teaching style

## Instructor: Example Questions

- What are the most critical aspects of instructor effectiveness?
- What is the ideal mix of subject matter expertise and teaching experience?
- What makes a good mentor?

# Learning Theme Categories

## Delivery Media

3) Classroom aids and environment
4) Distance learning
5) Simulation-based instruction
6) Computer-based instruction
7) Embedded training

## 3) Classroom aids/environment

- Aids – e.g., concept maps, videos
- Environment – noise, lighting, music

- Example Question:
  - What aids are most conducive to learning?

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## 4) Distance learning

- Defined as learning without physical co-location of information and learners
- Examples include e-learning, m-learning (learning with mobile devices such as iPads)

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## Distance learning: Example Questions

- What skills are most conducive to the use of distance education?
- Do skills taught via distance education show similar rates of decay?

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## 6) Computer-based instruction

- Using computers as part of training and education delivery
- Varying levels of complexity, ranging from low (e.g., typing tutor) to intelligent tutoring systems
- Animation and interactive microworlds

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## Computer-based instruction: Example Questions

- Can computer-based training accelerate learning?
- Can computer-based training facilitate better levels of transfer to work performance?

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## 7) Simulator-based instruction

- Simulation – working representation of reality used to represent devices and processes – provides cues to trigger learner responses
- All kinds of human-in-the-loop (HBR) and VR-based instruction
- Ranges from low to high fidelity virtual environments

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## Simulator-based instruction: Example Questions

- How much fidelity is enough?
- What tradeoffs can be made between simulation-based instruction and actual flight time / range time/ sea time?
- In team environments, can SBI models substitute for team members?

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## 5) Embedded training (ET)

- Training that is built into or added to a weapon system

~Witmer & Knerr, 1996

- Embedded, appended, or umbilical
- Allows for continual training

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## ET: Example Questions

- What is the most effective process to design, develop, and test ET solutions?
- How can new technology such as fused reality be used to enhance performance?

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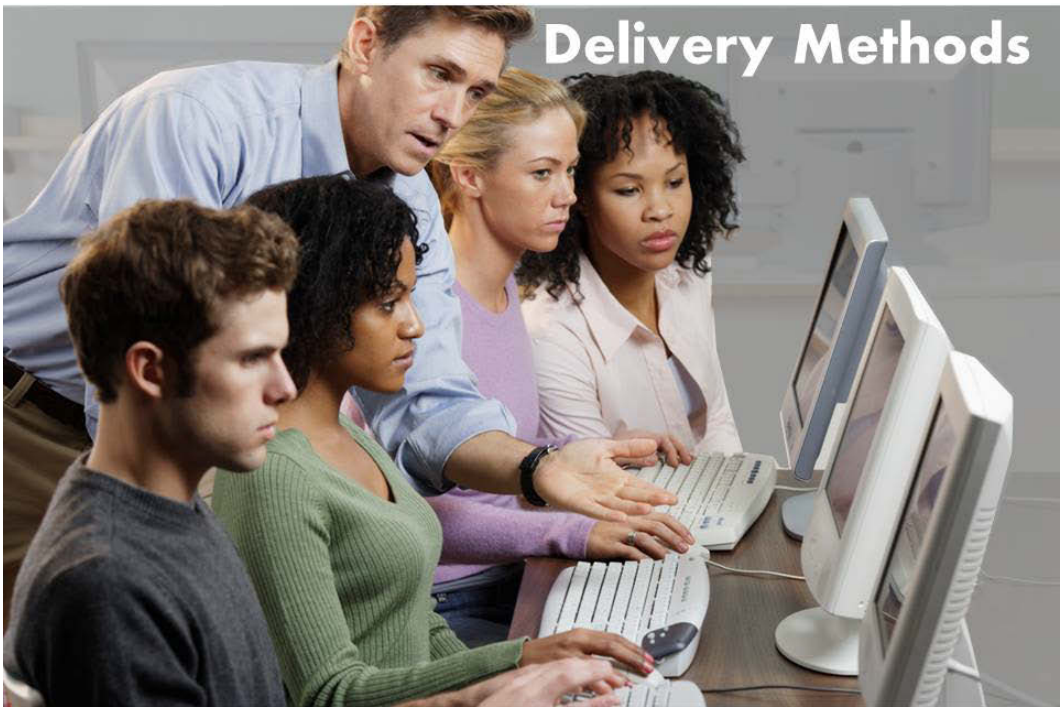
## Learning Theme Categories



## Delivery Methods

8) Collaborative learning
9) Scheduling
10) Feedback and testing
11) Adaptive instruction
12) Context and content

## 8) Collaborative learning

- Approaches that require joint intellectual efforts by one or more students
- E.g. – social networking tools such as Facebook, Twitter etc.

- Example Question:
  - Do collaborative tools promote learning?

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## 9) Scheduling

- When and how should practice and testing occur
- Timing, duration and spacing (e.g., massed vs. distributed) of training and practice
- Different ways to schedule training (e.g., just-in-time training, time compressed)

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## Scheduling: Example Questions

- How should practice be scheduled (spaced or massed) for varying types of skills?
- What is the relative effectiveness of different training schedules?

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## 10) Feedback and testing

- What type of feedback (outcome, process, intrinsic)?
- Frequency of feedback (continuous, intermittent
- Timing – immediate vs. delayed
- Source – peers, instructor, system

## Feedback and testing: Example Questions

- What are the optimal rates of feedback?
- What are the optimal rates of testing?

## 11) Adaptive instruction

- Tailoring of training and education to the needs of the individual (e.g., intelligent tutoring)
- More interesting for students and as well as increasing their motivation and consequently their learning
- Use of neuroscience to guide adaptation

## Adaptive instruction: Example Questions

- What types of adaptive instruction are most critical to promoting accelerated learning (e.g., rate of presentation, practice?)
- How can neuroscience best be applied to military teams?

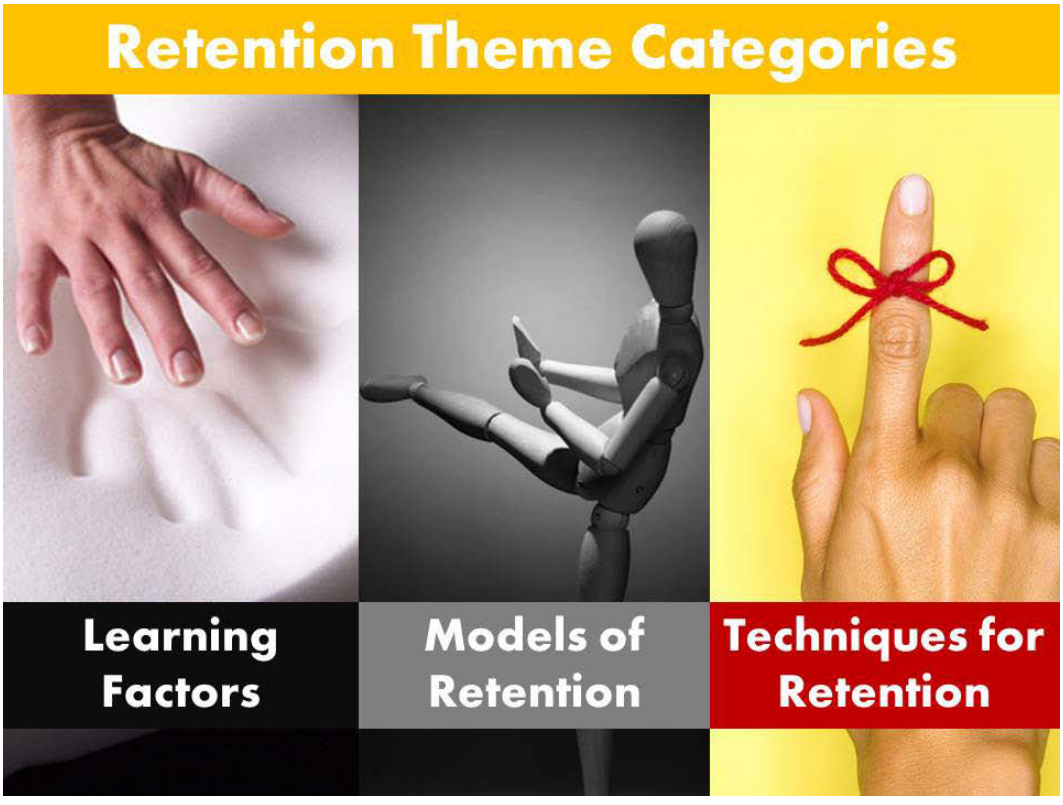
## 12) Context and Content

- Teaching why vs. how or what
- Environment – stress, cognitive workload, difficulty
- Content – cross-training, mixing team members, overlearning, "tough" cases

## Context and Content: Example Questions

- Can overlearning help to accelerate learning?
- How much stress is best?
- Is cross-training a good method of promoting learning and retention?

Two Theme Categories
Learning
Retention


Retention Theme Categories
Learning Factors
Models of Retention
Techniques for Retention

## Retention Theme Categories

## 13) Relationships to Learning Factors

- Maintenance of learned behaviours without practice
- Implications of skill/knowledge acquisition for retention

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## Relationships to Learning Factors: Example Questions

- **Does acceleration of learning impact negatively on retention?**

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## 14) Models of knowledge/skill retention

- Skills decay at different rates
- How long will skills/knowledge last?
- When is refresher training necessary?

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## Models of knowledge/skill retention: Example Questions

- Can models of skill retention predict skill decay?

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## 15) Techniques for Retention

- Techniques intended to develop or aid memory
- E.g., mnemonics (acronyms, poems)

- Example Question:
  - What retention techniques are the most effective? (e.g., mental rehearsal)

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## Summary of Learning Topics

1) **Student attributes**
2) **Instructor attributes**

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## Summary of Learning Topics (continued)

**Delivery Media**

3) **Classroom aids/environment**
4) **Distance learning**
5) **Embedded training**
6) **Computer-based instruction**
7) **Simulator-based instruction**

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## Summary of Learning Topics (continued)

**Delivery Methods**

8) Collaborative learning

9) Scheduling

10) Feedback and testing

11) Adaptive instruction

12) Context and Content

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## Summary of Retention Topics

13) Relationships to learning factors

14) Models of knowledge/skill retention

15) Techniques for Retention

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# Conclusion

- **Fifteen (15) topics emerged related to learning and retention**
- **Workshop discussions will further elaborate on the value of these topics**

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# Annex E Rating Matrix – Topic by Criteria Ratings

| Topics | G. – The anticipated results of addressing the topic will accelerate learning and/or improve retention. | H. – The anticipated results will be relatively easy to implement. | I. – National or international collaboration on this topic is possible. | J. – The topic will attract an industrial stakeholder for R&D. | K. – There is sufficient capability and/or capacity within Canada to take on this topic for R&D. |
|---|---|---|---|---|---|
| Student attributes | 3.62 | 2.17 | 3.73 | 2.50 | 4.10 |
| Instructor Attributes | 4.23 | 2.50 | 3.83 | 2.50 | 4.09 |
| Classroom aids/ environment | 3.31 | 3.15 | 3.82 | 3.60 | 3.92 |
| Distance learning | 3.46 | 3.17 | 4.00 | 3.92 | 4.00 |
| Embedded training | 3.91 | 2.50 | 3.85 | 4.00 | 3.44 |
| Computer-based Instruction | 3.38 | 3.46 | 4.08 | 4.36 | 4.17 |
| Simulator-based instruction | 3.85 | 2.62 | 4.54 | 4.62 | 4.09 |
| Collaborative learning | 3.69 | 3.27 | 4.31 | 3.00 | 4.00 |
| Scheduling | 3.58 | 2.42 | 2.57 | 2.14 | 3.67 |
| Feedback and testing | 4.00 | 3.23 | 3.90 | 3.22 | 3.67 |
| Adaptive instruction | 3.69 | 2.42 | 3.67 | 3.70 | 3.10 |
| Context and content | 3.50 | 2.73 | 3.67 | 3.18 | 3.67 |
| Retention- Relationships to learning factors | 3.56 | 2.67 | 3.43 | 2.50 | 3.43 |
| Models of knowledge /skill retention | 4.25 | 2.67 | 3.75 | 2.60 | 3.27 |
| Techniques for retention | 3.85 | 2.91 | 3.75 | 2.78 | 3.73 |

| Topics | A. – The topic has scientific merit. | B. – The topic is novel or innovative in addressing learning and retention. | C. – The topic aligns with and supports CF/DND goals. | D. – The topic will have wide application within CF/DND. | E. – The topic will improve organizational efficiency and/or effectiveness. | F. – The topic will address identified gaps - learning and retention deficits - in the CF/DND. |
|---|---|---|---|---|---|---|
| Student attributes | 3.85 | 3.23 | 4.25 | 4.31 | 4.08 | 3.55 |
| Instructor Attributes | 3.92 | 3.00 | 4.08 | 4.62 | 4.38 | 4.27 |
| Classroom aids/ environment | 3.46 | 2.92 | 3.25 | 3.62 | 3.69 | 3.25 |
| Distance learning | 3.62 | 3.08 | 4.38 | 4.31 | 4.25 | 2.92 |
| Embedded training | 4.17 | 3.62 | 4.00 | 3.77 | 3.83 | 3.45 |
| Computer-based Instruction | 3.77 | 3.38 | 3.75 | 3.69 | 3.64 | 3.20 |
| Simulator-based instruction | 4.54 | 3.77 | 4.38 | 4.08 | 3.85 | 3.50 |
| Collaborative learning | 3.85 | 3.77 | 3.91 | 4.33 | 4.18 | 3.50 |
| Scheduling | 3.09 | 3.20 | 3.17 | 3.58 | 3.45 | 3.58 |
| Feedback and testing | 4.08 | 2.92 | 4.17 | 4.00 | 3.92 | 3.64 |
| Adaptive instruction | 4.46 | 4.15 | 3.62 | 3.17 | 3.38 | 3.50 |
| Context and content | 4.23 | 3.69 | 4.08 | 4.00 | 4.00 | 3.00 |
| Retention-Relationships to learning factors | 4.36 | 3.91 | 3.78 | 3.56 | 3.89 | 3.75 |
| Models of knowledge /skill retention | 4.08 | 3.85 | 3.75 | 4.00 | 3.83 | 3.67 |
| Techniques for retention | 4.17 | 3.69 | 3.92 | 4.00 | 3.85 | 3.42 |

# List of symbols/abbreviations/acronyms/initialisms

| | |
|---|---|
| DND | Department of National Defence |
| DRDC | Defence Research & Development Canada |
| DRDKIM | Director Research and Development Knowledge and Information Management |
| R&D | Research & Development |

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Defence Research and Development Canada (DRDC) Toronto and the Canadian Defence Academy (CDA) have embarked upon a collaborative research effort to identify the most promising topics for Research and Development (R&D) on accelerating learning and maximizing knowledge/skill retention that could yield the greatest benefit to the Canadian Forces (CF) within five years. This report examines the two deliverables of this project, a literature review and a workshop.

The literature generated a list of potential research concepts related to accelerated learning and retention. A review 26 articles from the relevant literature showed a range of factors likely to impact on learning and retention. These included characteristics of the student (e.g., cognitive ability and motivation), the instructor, delivery media (e.g., classroom-based instruction vs. computer-based instruction), delivery methods (e.g., scheduling, feedback and testing) and issues related to retention. It was noted that the factors that influence skill acquisition are not necessarily the same ones that influence skill retention. The literature review examined the available research exploring the impact of these factors on learning and retention, and identified gaps and emerging research questions.

Following the identification of these 15 research topics, a workshop (coordinated and facilitated by the CDA) was convened in Kingston in order to explore the merit and importance of these topics from the perspective of subject matter experts, in order to guide future research and development efforts. Thirteen stakeholders, representing Navy, Army and Air force, discussed and provided ratings on each of the 15 topics on each of 11 evaluation criteria such as the scientific merit of the topic area, its alignment with CF/DND goals, and the potential for national or international collaboration on the topic.

Quantitative results showed that simulator-based instruction was rated as being the most promising area for future research, followed by instructor attributes, collaborative learning, distance learning and computer-based instruction. Participants also provided rich insights about each of the 15 topic areas, and raised potential research questions that could be addressed in future research and development efforts.

Recherche et développement pour la défense Canada (RDDC) - Toronto et l'Académie canadienne de la Défense (ACD) collaborent à un projet de recherche sur les sujets de recherche et développement les plus prometteurs concernant les façons d'accélérer l'apprentissage et de maximiser la conservation des connaissances et des compétences acquises qui pourraient être les plus avantageuses pour les Forces canadiennes (FC) au cours des cinq prochaines années. Le présent rapport fait le point sur deux réalisations du projet : une analyse de la documentation parue sur le sujet et un atelier.

L'analyse de la documentation a permis d'extraire une liste de concepts de recherche potentiels liés à l'apprentissage accéléré et à la conservation des connaissances. L'analyse de 26 articles a mis au jour une gamme de facteurs susceptibles d'influer sur l'apprentissage et la conservation des connaissances acquises. Il s'agit notamment des caractéristiques de la personne qui apprend (p. ex. : sa capacité cognitive et sa motivation), de l'instructeur, des moyens utilisés pour donner la formation (p. ex. : enseignement donné en classe ou enseignement informatisé), des méthodes d'enseignement utilisées (p. ex. : établissement du calendrier de formation, rétroaction et examens) et des questions relatives à la conservation des connaissances acquises. On a fait observer que les facteurs qui influent sur l'acquisition des compétences ne sont pas nécessairement les mêmes que ceux qui influent sur la conservation des connaissances et des

compétences acquises. Lorsqu'on a analysé la documentation sur le sujet, on s'est penché sur l'incidence de ces facteurs sur l'apprentissage et la conservation des connaissances et on a relevé des lacunes ainsi que des nouvelles questions sur la recherche. Après avoir recensé quinze sujets de recherche, on a organisé un atelier (coordonné et animé par l'ACD) à Kingston au cours duquel on a exploré les mérites et l'importance de ces questions du point de vue des spécialistes pour guider les travaux futurs de recherche et de développement. Treize intervenants, représentant la Marine, l'Armée de terre et la Force aérienne, ont participé aux discussions et coté chacun des quinze sujets en regard de chacun des onze critères d'évaluation, comme le mérite scientifique de la discipline concernée, sa pertinence par rapport aux objectifs des FC ou du MDN et le potentiel de collaboration au niveau national ou international.

Les résultats quantitatifs obtenus montrent que l'instruction par simulateur est considérée comme le secteur le plus prometteur pour la recherche future, suivie des caractéristiques des instructeurs, l'apprentissage en collaboration, l'apprentissage à distance et l'instruction par ordinateur. Les participants ont également donné des points de vue très éclairés sur chacun des quinze sujets et fait part de questions de recherche potentielles pour les futurs travaux de recherche et de développement.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

learning; military training; retention; memory; skill decay